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Soils Number

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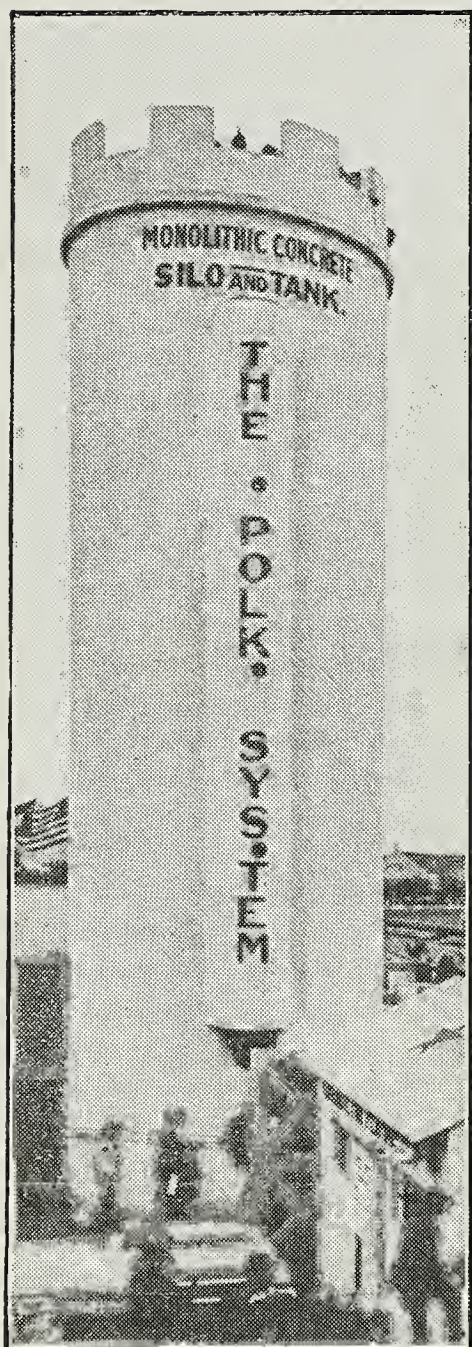
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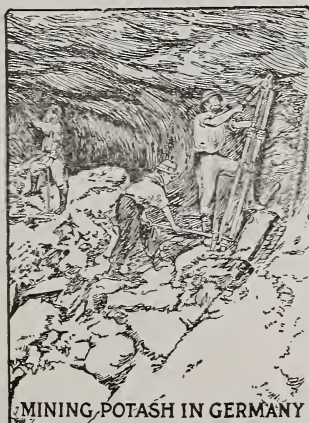
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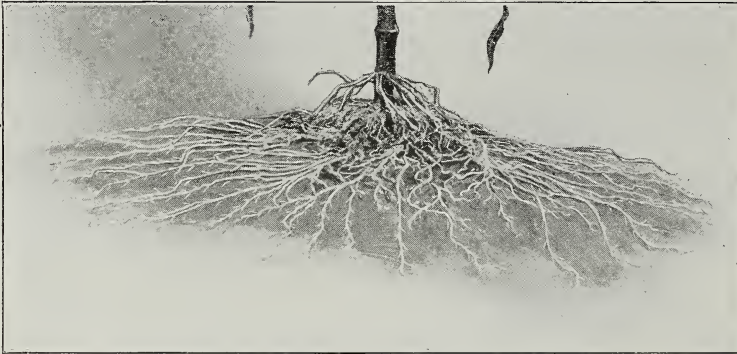
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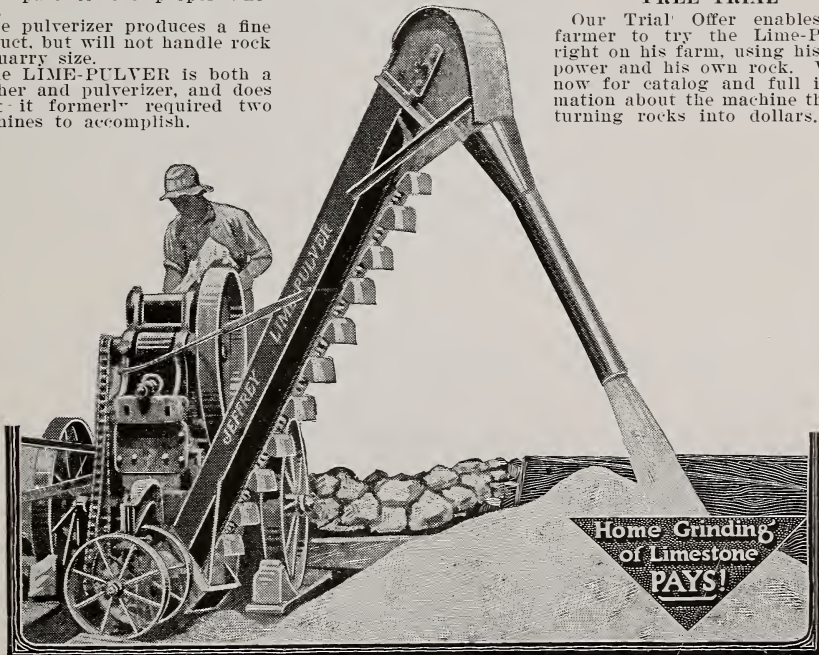
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THE AGRICULTURAL STUDENT

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OHIO STATE UNIVERSITY, COLUMBUS, JANUARY, 1916

No. 5

SOME EXTREMES FOUND IN OHIO SOILS

Comparison of the Lands, Crops and Experiments in Clermont and Paulding Counties: Their Response to the Use of Fertilizers and the Fertility Problems of Each Section.

CHARLES E. THORNE, Director, Ohio Agricultural Experiment Station, Wooster, Ohio

AGRICULTURALLY, Clermont County is one of the oldest counties in Ohio. Adjoining Hamilton, in which Cincinnati is located, and with a large frontage on the Ohio river, it has had the advantage of a good market. It was settled at an early date, and since 1850 there has been no increase in the area devoted to the cereal crops.

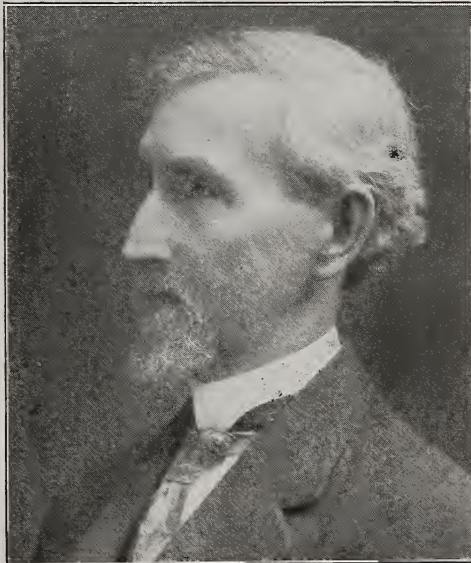
The topography of Clermont County is very hilly along the Ohio river and the two branches of the Little Miami, but a large part of the interior is occupied by a level plateau, lying several hundred feet above the bottom lands of the valleys. Much of this upland is so flat that it was originally covered with water a large part of the year, until the forest was cut away, when the decaying roots furnished drainage channels and the land became dryer. But with continued cultivation these drainage channels have been obliterated and the land now stays wet until late in the spring.

The surface soil of the upland is a

fine-grained, gray or yellowish-gray silt loam. Very little drainage has been done in this region, the opinion being prevalent that tile drains will not work successfully, either through failure of the water to find its way to them or through filling up with silt.

The Clermont County experiment

farm was located on this upland soil in 1911, fronting the old turnpike between Cincinnati and Hillsboro and 25 miles from Cincinnati. For half a century its principal crop had been timothy hay, grown chiefly for the Cincinnati market, and as a preparation for its work it is being thoroughly drained with tile. If it should prove im-



possible to drain this land, the wisest use that could be made of it would be to return it to forest. The price paid for this farm was \$50 per acre.

Paulding County was not organized as a separate county until 1820, and in 1840 its population was only 1025—being less at that time than that of any other county in the State. Its topography is that of a flat plain, which was

originally covered much of the year with water, and was occupied with an unbroken forest of elm and other semi-aquatic trees. The conditions were such over most of the county as to necessitate the construction of large open ditches or canals, sometimes several miles in length, to serve as outlets for the farm drains; enterprises requiring special legislation and cooperative ef-

the bottom. These ditches are in the swales or lowest places, often not discernible to the eye, and which the engineer's level alone can detect. Thousands of acres are now drained and in time the entire county will be so, when it will be one of the most level and fertile tracts anywhere, producing enormous crops, especially grass."

The soil of the larger part of the

TABLE I—Ten-year Average Acreage and Yield Per Acre of Corn, Oats and Wheat.

PERIOD.	Clermont County.		Paulding County.	
	Acres.	Bushels.	Acres.	Bushels.
Corn—				
1850-59	35,599	33.3	2,810	31.8
1860-69	35,563	28.8	4,690	28.9
1870-79	40,832	30.0	9,656	29.3
1880-89	35,772	26.6	13,565	31.4
1890-99	35,377	25.5	32,122	38.1
1900-09	36,781	24.8	46,710	38.6
Wheat—				
1850-59	22,607	11.8	1,208	11.1
1860-69	21,488	8.8	3,493	10.9
1870-79	16,048	10.2	5,805	12.8
1880-89	18,630	8.9	11,722	12.5
1890-99	21,751	9.9	16,952	12.9
1900-09	12,874	11.1	13,101	16.4
Oats—				
1850-59	10,240		345	13.4
1860-69	13,563	19.7	861	19.7
1870-79	13,344	18.8	3,026	26.2
1880-89	13,369	18.7	4,248	28.3
1890-99	8,057	16.9	9,013	32.9
1900-09	9,836	20.1	31,603	35.6

fort, and it was near the end of the century before any general system of drainage was in operation. Writing in 1886, Howe, in his "Historical Collections of Ohio," says:

"The county is being ditched extensively under the State statutes. An engineer appointed by the county commissioners lays out the ditches and dictates the dimensions. They vary from 3 to 6 feet deep and from 7 to 20 feet in width, and from 6 to 9 feet wide at

county is classified as Clyde clay, a dark brown to almost black, heavy or silty clay, very sticky when wet and becoming so hard when dry that it plows up in clods difficult to pulverize. There is probably no soil in Ohio, excepting some of the red clays in the southeastern counties, for which the optimum time for plowing—between the too wet and the too dry—is so short and of such importance as for the Clyde clay. When worked in proper condi-

tion this soil is productive, and the drained lands of Paulding County have attained a very high market value.

Howe states that as late as 1878 wild timbered lands could be bought within four miles of Pauding for from \$4 to \$6 per acre, and that in 1886 improved lands were held at \$30 to \$50. But by 1911, when the county experiment farm was located, the forest had disappeared, except for small groves here and there. The county was crossed in both direc-

small orchard, two large open ditches and some tile drains, which were too far apart and too shallow for effective service.

The cereal production in Clermont and Paulding Counties for the 60 years for which statistics have been collected is shown by 10-year averages in Table 1:

Table 1 shows that the area in corn, oats and wheat had practically reached its maximum in Clermont County by 1850, whereas in Paulding County it



Fertilized and Unfertilized Plots of Corn on Clermont County Experiment Farm

tions by well made roads, many of them macadamized and often having great ditches alongside; many of the farms had been tile drained with lines four to six rods apart, and such lands were held at \$150 to \$200 per acre, while the average valuation for the county, as given in the census of 1910, was \$87.37, as against \$31.39 in Clermont County.

A tract of this description, containing 92 acres, from which the timber had all been removed, was purchased for the experiment farm at \$175 per acre. It contained no improvements except a

did not reach this point until 50 years later. During the first half of the 60 years the yield per acre of corn was greater in Clermont than in Paulding County, but during the last half the yield in Clermont has fallen off, while that in Paulding has increased. Comparing by 30-year periods, there has been in the corn crop an average loss of five bushels per acre in Clermont and a gain of six bushels in Paulding, and in the wheat crops, a drop from 10.3 to 10 bushels in Paulding. Apparently the yield of oats has remained stationary

at 20 bushels or less per acre in Clermont County and has gained 12.5 bushels in Paulding County.

Four questions suggest themselves respecting the present condition of agriculture in these flat lands.

1. Are the larger yields in Paulding County wholly due to natural superiority of soil, or has the better drain-

rotation, manuring and fertilizing, to obtain as large a net increase from the Clermont as from the Paulding soil, taking into account the difference in rental value?

4. How may the rate of yield in Paulding County be maintained or further increased?

In order to obtain some light on these

TABLE II—Plan of Fertilizing in Corn, Oats or Soybeans, Wheat, Clover Rotation, Paulding and Clermont County Experiment Farms.

Plot No.	On Corn.				Pounds Per Acre.					
					On Oats or Soybeans.			On Wheat.		
	Acid Phosphate.	Muriate of Potash.	Nitrate of Soda.	Ground Limestone.	Acid Phosphate.	Muriate of Potash.	Nitrate of Soda.	Acid Phosphate.	Muriate of Potash.	Nitrate of Soda.
1	...	...	...	...	...	...	...	...	...	...
2	200	...	...	...	100	...	...	200	...	...
3	200	50	...	...	100	20	...	200	20	...
4	...	...	...	...	...	...	...	...	...	...
5	200	50	50	...	100	20	30	200	20	80
6	200	50	50	2,000	100	20	30	200	20	80
7	...	...	...	...	...	...	...	...	...	...
8	Phos.† manure	8 tons	...	...	...	...	...	200	50	50
9	Phos. manure	8 tons	...	2,000†	...	...	...	200	50	50
10	...	...	...	...	...	...	...	...	...	...

†Manure not phosphated for Plot 8 in Paulding County.

‡No limestone on Plot 9 in Paulding County.

age in that county been an important factor in increasing the yields?

2. May the present rate of production in Paulding County be expected to continue indefinitely, or is it probable that a decline in yield, similar to that which has occurred in Clermont County, will take place after the land has been as long in cultivation as has that in the latter county?

3. Is it possible, by drainage, crop

questions, a four-year rotation of corn, oats or soybeans, wheat and clover, was begun on the experiment farm in each county in 1912, the second crop in the rotation being oats in Paulding County and soybeans in Clermont County.

Four blocks of land, A, B, C and D, containing 10 plots each, are included in the experiment, so that each crop will be grown every season after the

first rotation. The plots contain one-tenth acre each and receive fertilizers, lime and manure according to the plan shown in Table II, the treatment in both experiments being the same, except that in the Paulding County test, plot 8 receives untreated manure and plot 9 is not limed.

Although the crops have not all come under the plan of treatment as yet, and therefore cannot show its full effect, it is interesting to study the results thus far obtained.

The Corn Crops—In starting this experiment in Clermont County, corn was grown in 1912 on block D, in 1913 on A and in 1914 on B, this being the first fertilized crop on each block, and being grown on land that had had no clover for an unknown period. The average yield of these three crops ranged from 12 to 23 bushels per acre on the unfertilized land, which had apparently been about the average yield of this land during recent years. (The average yield for the county as a whole for 1900-1909, was 28.4 bushels per acre, but this average includes the yields of the valley lands, where the corn crop is chiefly produced). The highest point reached on the fertilized or manured land in the experiment during these three years was 37.7 bushels for the complete fertilizer and limestone and 35.7 bushels for the manure and limestone, in 1913.

Wheat was grown on block C in the fall of 1912, and was followed by a very light crop of clover, but the corn crop of 1915, grown on this block, had the advantage of the residues of fertilizer left by the wheat, and of the small clover crop, and was able to reach a yield of 27 bushels per acre on the unfertilized land, and of 65 bushels on the average of the two manured plots.

How much of this year's outcome may be due to exceptionally favorable

seasonal conditions remains for the future to determine, but in the average of the four years the cost of most of the applications has been recovered in the corn crop, without considering the effect on the following crops of the rotation.

In the Paulding County experiment no definite effect can be traced to fertilizers, lime or manure, the yield on the treated land being as often below as above that on the unfertilized land. The highest yields attained in this test were in 1912, when the average of the ten plots was 63 bushels per acre, or slightly less than the highest yields reached in the Clermont County test on the manured land. Whether such yields can be maintained on the Clermont soil is for the future to determine.

The Soybean Crops—Because of lack of facilities for threshing the soybeans, the total product is reported as hay in Table III. Each of the three crops thus far grown in their regular place in the rotation has been grown on land not previously occupied with this crop, and the yields have been light. The possibilities of the soybean crop, however, are shown by a crop grown in 1915 in place of clover, which had failed, thus bringing the beans on the same land in 1913 and 1915. The average unfertilized yield of this crop was two tons of total produce per acre, and more than three tons was taken from the manured land, as against less than half these yields for the same season on land on which soybeans had not previously been grown.

The Oat Crops in the Paulding County test indicate a slight increase in yield from the fertilizers carrying both nitrogen and potassium, but the results are too irregular to justify definite conclusions.

The Wheat Crops have averaged, on the unfertilized land, 7.0, 4.4 and 13.2

bushels per acre in the Clermont County test for 1913, 1914 and 1915, respectively, as against 42.1, 27.3 and 43.1 bushels in the one in Paulding County.

In the Clermont test every treatment with fertilizers or manure has increased the yield, the maximum being 29.3 bushels for the complete fertilizer and limestone and 29.7 bushels for phosphated manure and limestone in 1915.

In the Paulding test the yields of

all the fertilizing applications, the yields being 28.6 bushels for phosphorus, 28.2 for phosphorus and potassium, 33.7 for the complete fertilizer without lime, 30.8 for the same with lime, 32.7 for manure alone and 31.4 for manure with lime. But with a three-year average yield on unfertilized land of 37.5 bushels, it is not to be expected that much further increase can be obtained.

TABLE III—Clermont County Experiment Farm: Average Results for First Four Years.

Plot No.	Treatment.	Average Yield Per Acre.				Annual Value of Produce.	Annual Cost of Treatment.	Net Value of Produce.
		Corn, Bushels.	Soybeans, Pounds.	Wheat, Bushels.	Hay, Pounds.			
	None	18.9	1,346	8.5	2,271	\$ 8.80	\$	\$ 8.80
2	Phosphorus	25.5	1,533	12.4	2,726	11.30	0.90	10.90
3	Phosphorus Potassium	27.4	1,457	13.7	2,618	11.60	1.45	10.15
5	Phosphorus Potassium Nitrogen	31.7	1,827	17.9	3,059	14.10	2.65	11.55
6	Phosphorus Potassium Nitrogen Limestone	32.5	2,187	19.5	3,033	14.97	4.15	10.82
8	Manure Phosphated	39.4	1,877	16.1	4,115	16.04	3.60	12.44
9	Manure Phosphated Limestone	39.5	1,823	19 2	4,385	17.02	5.10	11.92

wheat have averaged between a minimum yield on unfertilized land of 27.3 bushels per acre in 1914 and a maximum of 48.3 bushels for untreated manure in 1915. In the three-year average, fertilizers carrying nitrogen and manure have apparently produced a slight increase, while phosphorus alone or with potassium has given less wheat than the untreated land. In 1914, however, with an unfertilized yield of 27.3 bushels, there was some increase from

The Clover Crops—Clover has apparently been a stranger on the Clermont County farm for many years. The first crop to come under experiment was that of 1914, which gave an average yield of 331 pounds per acre on the unfertilized land, increasing to 1400 pounds on the manured land; but in 1915 the clover failed entirely and was plowed up and soybeans were sown instead. The beans were harvested as hay, making two to three tons per acre.

On the Paulding County farm the two crops of clover have averaged 3700 pounds per acre on the unfertilized land, but both lime and phosphorus, if they have had any effect, have reduced the yield.

The average outcome of the two experiments is summarized in Tables III and IV, in which corn is valued at 50 cents per bushel, oats at 33 cents, wheat at 90 cents and hay—clover or soybean—at \$10 per ton.

be of equivalent amounts of nitrogen, phosphorus and potassium in commercial fertilizers.

Table III shows that in the Clermont County test every application of fertilizing materials has brought a profitable return, the value of the produce being increased from an average of \$8.80 per acre on the unfertilized land to from \$10 to \$12 on the fertilized and manured land. The limestone has increased the yield, but not quite enough



Joe Wing Preaching "Lime for the Soil." Director Thorne in Background.

The fertilizers have been rated at \$14 per ton for acid phosphate, \$50 for muriate of potash and \$60 for nitrate of soda—prices sufficiently high to cover their cost before the European war, and to which they will probably return when the war is ended. Powdered limestone is rated at \$3 per ton, spread on the land, and manure at \$1 per ton. This value for manure is more than its necessary cost when produced on the farm, though less than the cost would

as yet to return its cost, and the same may be said of the potassium.

Table IV shows that in the Paulding experiment no treatment with fertilizers, lime or manure has as yet produced sufficient increase to repay its cost. In the case of the wheat crop, as stated above, we could hardly expect much increase over an unfertilized yield of 37½ bushels, but the yields of the other three crops are not so large but that there is room for improvement. As

stated at the outset, however, this work has not yet been carried far enough to justify definite conclusions. It seems worth while, nevertheless, to bring together the results of the first round of cropping in these experiments to serve for comparison with the outcome of future work.

At 6 percent, the annual interest on the cost of an acre of the Paulding County experiment farm would be \$10.50, and on that of the Clermont

the difference would hardly offset the interest on the cost of the Clermont County land.

At this stage of the game, therefore, it would seem that, as a business proposition, the Paulding County farm was a better investment at \$175 per acre than the Clermont County farm at \$50; but it would be very unwise to accept this comparison as demonstrated, for it remains to be seen whether the rate of production in Paulding County will

TABLE IV—Paulding County Experiment Farm: Average Results for First Four Years.

Plot No.	Treatment of Previous Crops.	Average Yield Per Acre.				Annual Value of Produce.	Annual Cost of Treatment.	Net Value of Produce.
		Corn, Bushels.	Oats, Bushels.	Wheat, Bushels.	Hay, Pounds.			
	None	52.0	49.0	37.5	3,700	\$23.64	\$	\$23.64
2	Phosphorus	47.3	48.2	36.0	3,506	22.41	0.90	21.51
3	Phosphorus Potassium	46.8	51.2	36.6	3,834	23.14	1.45	21.69
5	Phosphorus Potassium Nitrogen	53.8	54.6	41.2	4,050	25.61	2.65	22.96
6	Phosphorus Potassium Nitrogen Lime	48.9	52.6	39.6	3,653	23.97	4.15	19.82
8	Manure Phosphated	52.9	47.2	41.1	4,279	25.14	2.00	23.14
9	Manure Phosphated	47.1	46.1	39.6	3,872	23.48	3.60	19.88

County farm \$3. Deducting \$10.50 from \$23.64, the value of the unfertilized yields on the Paulding County farm would leave \$13.14—a greater sum than the net value of the produce in any of the treatments in Clermont County, unless manure be rated at less than \$1 per ton, without making any deduction for rent or interest.

It has, of course, cost more to harvest and market the Paulding County than the Clermont County crops, but

be maintained without some expenditure for fertilizers or manure, and whether that of Clermont County may not be advanced to a higher plane when the full effect of treatment shall have had time to become manifest. For example, the average annual gross value of the increase from the fertilizers and manure used in the five-year rotation at Wooster was \$5.31 per acre for the first 5-year period, \$5.89 for the second, \$7.55 for the third, \$8.95 for the fourth.

HUMUS—THE KEYSTONE OF FERTILITY

How a Barren Soil Can Be Restored to Productiveness

ALFRED VIVIAN, Dean, College of Agriculture, Ohio State University

ANY soil which was once rich can again be made rich. The principal factor in restoring the fertility of the soil is the renewal of the organic matter which has been destroyed by constant tillage and cropping. When the original amount of organic matter in the soil is renewed, the soil will be as fertile as it was in the beginning.

A comparison of the chemical analysis of several virgin Ohio soils with adjacent soils which have been cropped for 100 years shows that more than one-third of the organic matter of the soil

and it is a matter of common experience that the crop yields are more often limited by an insufficient supply of available water than by any other one factor. (2) Organic matter improves the physical condition of the soil. It overcomes the stickiness and tenacity of the clays, and makes the sandy soils more compact and more able to hold water. In other words, it converts either sand or clay into loam, and loam is a word to conjure with. (3) Organic matter is a storehouse of plant-food especially of the nitrogen



has been destroyed. The decrease in fertility of the soil has been coincident with its decrease in organic matter.

Why is organic matter essential to a fertile soil? (1) It increases the capacity of the soil for holding water in a form in which it is available to plants. Organic matter absorbs from ten to twelve times its own weight in water and holds this water so loosely that it can be absorbed by the root hairs of the growing plants. An increase of one percent of organic matter in the soil, therefore, gives the soil the ability to hold at least ten percent more water

of the soil. It also makes possible the life and action of the innumerable bacteria found in the soil. During the decomposition of the organic matter, various acid substances are formed which, in their turn, act upon the mineral matter of the soil and convert it into forms which are available to the plant. Under nature's conditions, it is only soils well stocked with organic matter which are fertile. One of the most important matters to be considered in the maintenance of soil fertility, then, is the most economic method of adding organic matter to the soil.

This may be done: (1) By completely utilizing all of the plant residues. The stubble and the sod should be plowed under and the ground should never be burned over, as is too often done. All straw and stalks and, in fact, all waste organic matter of the farm should be incorporated with the soil to add to its content of organic matter. (2) The organic matter of the soil can be increased by proper care and utilization of the manure produced on the farm. When crops are fed to animals, the manure contains one-half as much organic matter as was contained in the crop, and if the manure is properly saved, it becomes an important factor in maintaining the yield of the crops. (3) Organic matter can be added to the soil by the use of the so-called "catch-crops." These are plants grown between the important crops of the farm for the purpose of providing some green material to plow under. The planting of rye or vetch at the last cultivation of corn is the most familiar example of the use of the catch-crop. Under some conditions of farming this method may prove of great value in

keeping up the fertility of the soil. (4) The organic matter in the soil may be increased by the method commonly known as green-manuring. In this case the entire growing season is devoted to the production of the crop which is plowed under. The plant most ordinarily used for this purpose is clover, although field peas, soybeans and cow peas are well known green-manuring crops. Any system of farming which does not involve the feeding of animals will probably require the use of a green-manuring crop for at least one year in the rotation. In any system of animal husbandry, on the other hand, the feeding value of the crop is so high that only under extraordinary circumstances will it be sacrificed for the purposes of green-manuring.

The successful farmer of the future will be the man who will study his system of farming with a view of ascertaining its effect upon the organic matter of the soil, and who will make such adjustment of his system as will insure the return to the soil of an amount of organic matter equivalent to that which he has destroyed by tillage.



Organic Matter Wasting Away

TILLAGE—ITS PRINCIPLES AND DANGERS

How Cultivation Should Conserve the Organic Matter in Soil

DR. CHARLES B. LIPMAN, University of California, Berkely, California

WE have changed the form of the tillage by replacing the ancient pronged stick with a steel plow, and man power or horse power with steam power and electricity, but we still cling to the principal traditionally handed down to us from the ancients that tillage is beneficial to crop production.

Teachers and writers on tillage and soil management, from the scientific as well as practical standpoints, have ever exhorted the farmer to plow deeply and to cultivate early, frequently and

moisture, percolation is of course reduced and smaller quantities of soluble plant food components are carried away from the soil into the country drainage and ultimately to the sea. Still other experiments have shown that plowing increases the quantity of available plant food in the soil, and particularly the nitrate supply, through the beneficial effects of **aeration on the nitrifying and ammonifying bacteria.**

Plowing is the necessary and most effective mode of incorporating ma-



Tillage Increases the Available Plant Food in the Soil.

thoroughly. The reasons for the recommendation of such practices are to be found in the results of numerous experiments of many soil physicists in all parts of the world. Briefly, such results show that deep plowing, because it changes a more or less compacted soil layer into a very loose and fluffy one, it helps to aerate and warm the turned soil itself, as well as the soil below it, and creates a much larger amount of surface upon which the water of falling rain and snow may be caught and held. By thus increasing the soil's power to catch and retain

nure, rubbish, stubble and other forms of organic matter into the soil and of drying, and hence warming, wet soils sufficiently to make good seed beds for germination and development of seeds, roots and soil bacteria.

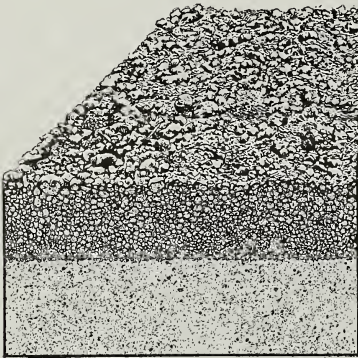
From the point of view of cultivation, the reasons are as follows: It destroys weeds, which rob crops of water and plant food; it forms a blanket of loose, dry soil, known as an earth mulch, which markedly decreases evaporation of water from the moist soil beneath; by its frequent use it prevents the natural compaction of even a

dry soil; lastly, it may assist in increasing the air supply for the soil.

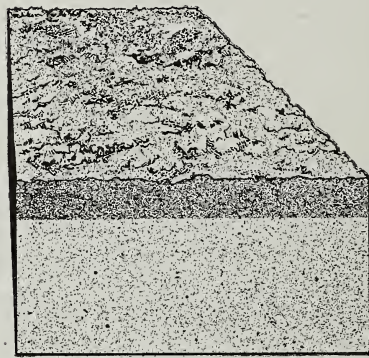
All of this, however, tells only part of the story. Just as we are told every right carries with it a corresponding duty, so every advantage in a tillage operation is not an unmixed benefit, any more than is every disadvantage an unmitigated evil. In studies on the humus and nitrogen economy of Minnesota soils which are constantly cropped to wheat, Snyder found that in a period of eight years there was lost over one ton of humus per acre at a conservative average estimate, and besides 1700

gallons particularly has called attention to the losses of humus and nitrogen from soils which accompany constant tillage, and has, perhaps, in this problem, as in many others, been the first to foresee its significance for the future of arid soils. He felt confident, however, when he wrote on the subject, that green manuring and the use of barnyard manure when available, offered feasible means for the maintenance of the organic matter supply in our soils.

Evidently, whatever benefits accrue from tillage, they are accompanied by



The right kind of a mulch for moisture conservation is granular—that is, the dirt should not be pulverized too finely.



The wrong kind of a mulch. The ground is almost dust. Such a mulch blows away easily.

pounds of nitrogen per acre, about 1350 pounds of which were lost through denitrification, gasification or leaching. Similarly, Ladd, at the North Dakota Agricultural Experiment Station, has noted large losses of humus and nitrogen from "humus rich" prairie lands of that state under the tillage management of grain land. These losses do not by any means include all the losses of organic matter from those soils, but merely a certain portion arbitrarily determined and named "humus."

Strangely enough, we have, in a vague way, recognized many of these facts without attempting to obviate the dangers to which they point. Hil-

gard particularly has called attention to the losses of humus and nitrogen from soils which accompany constant tillage, and has, perhaps, in this problem, as in many others, been the first to foresee its significance for the future of arid soils. He felt confident, however, when he wrote on the subject, that green manuring and the use of barnyard manure when available, offered feasible means for the maintenance of the organic matter supply in our soils.

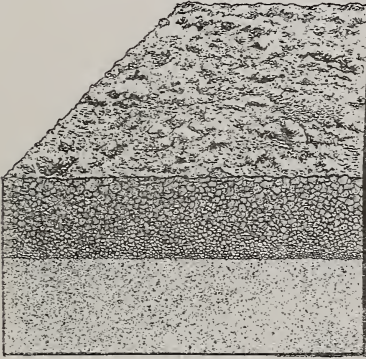
Evidently, whatever benefits accrue from tillage, they are accompanied by

a most serious disadvantage—the loss of organic matter from soils. That this is a most serious disadvantage becomes evident to the practical man when he notes that, through constant tillage, the natural weed growth becomes sparser and sparser, the soil clods and bakes when dry or is much more sticky when wet. It "runs together" badly. In beginning with a virgin soil we find good physical conditions even in our desert lands, but soon, under our system of cultivation, the structure of the soil becomes more and more injured in the manner just indicated. Tillage becomes more difficult, annual crops decrease in yields mark-

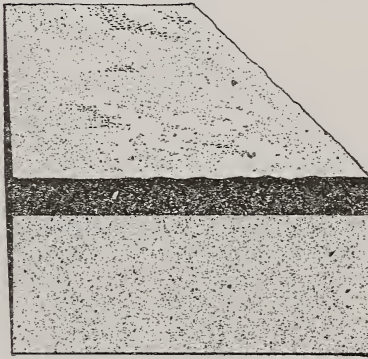
edly, our trees show sparser foliage of a lighter hue and make less growth, fruit becomes smaller and frequently less in quantity.

Since the bad physical conditions in soils just described result from the loss of organic matter, it becomes pertinent next to inquire how the organic matter is lost from the soil and why tillage assists such losses. Briefly, the elements of organic matter become oxidized into gaseous compounds, which dissipate into the atmosphere. Thus, for example, one of the chief components of soil organic matter is carbon. This is readily oxidized to carbonic acid gas and

tion along with high temperatures and long dry seasons make conditions which are particularly favorable for immense losses of organic matter, as indicated, hence the low "humus" content of arid soils and hence the rapidity of their change from the loose condition of their virgin state to the compact and alternately sticky and cloddy condition which characterizes them in their tilled state. To bring home with more telling effect the fact of such rapid disappearance of organic matter from soils under the activity of oxidation, I need but inquire if the reader has noted the enormous shrinkage



The granular mulch rained upon. Notice that a slight crust is formed on the surface. A peg-tooth harrow will break up the crust.



The dust mulch rained upon. The soil particles are compact and close together, forming a deep crust.

disappears into the atmosphere. So it may be also with other constituents of the soil organic matter. Such oxidation may be purely chemical or it may be bio-chemical. The loss of the jelly-like or colloidal organic compounds thus accomplished removes the cushion-like bodies which act at once as barriers to the intimate contact of sand and silt grains and as binding materials for the maintenance of such sand and silt grains into loose aggregates, to which we give the name "crumb structure." But destruction of crumb structure means a collapse of the soil and a change from a fluffy condition to a compact one. Constant cultiva-

tion along with high temperatures and long dry seasons make conditions which are particularly favorable for immense losses of organic matter, as indicated, hence the low "humus" content of arid soils and hence the rapidity of their change from the loose condition of their virgin state to the compact and alternately sticky and cloddy condition which characterizes them in their tilled state. To bring home with more telling effect the fact of such rapid disappearance of organic matter from soils under the activity of oxidation, I need but inquire if the reader has noted the enormous shrinkage

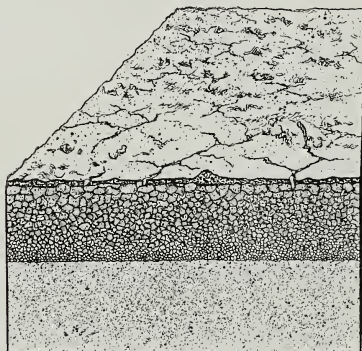
which manure, green organic matter, or in fact, any organic matter, suffers when allowed to lie in the open for any length of time? From all this it would appear that we can no longer assert without qualification that tillage helps to aerate soils, for any injured soil structure such as that to which I have referred must result finally in poor aeration. In other words, it is now more correct to say that tillage improves temporarily the air conditions in the soil and injures them, especially in soils in which the organic content is low.

That a certain amount of air is necessary in soils is beyond cavil. That

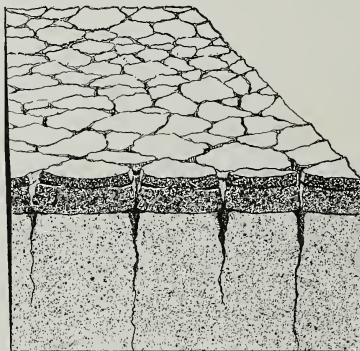
that certain amount is definitely known and its functions clearly understood now appears altogether doubtful. The writer, in common with many others, has always taught that roots must have air, just as animals and man must have it, but recent careful thought and observation renders it very doubtful if that is the case as stated. If roots must have as free a supply of air as animals, it seems strange that some of them can subsist normally at depths of ten, twenty, thirty or seventy feet. This fact would seem to indicate rather that small quantities of oxygen are sufficient for normal root development. We know

bacteria of several kinds which fix nitrogen from the atmosphere must have not only oxygen, but also nitrogen. Many other forms of micro-organisms in the soil, upon which depend the solution of minerals essential to plant growth, the oxidation of harmful to innocuous soil constituents, and many other processes which I could mention, must have a free supply of air. It seems, therefore, that air is needed in large quantity for the soil and its teeming population, but probably only in very small quantity for the roots of plants themselves.

While the temporary effects of plow-



The granular mulch rained upon and left standing for a number of days. Observe that the ground is cracking, and that moisture is escaping through these cracks. The crust can be easily broken.



Dust mulch rained upon and left standing in the hot sun. Note that the crust has cracked, and that the moisture is escaping very rapidly. It is impossible to work up this seed bed properly.

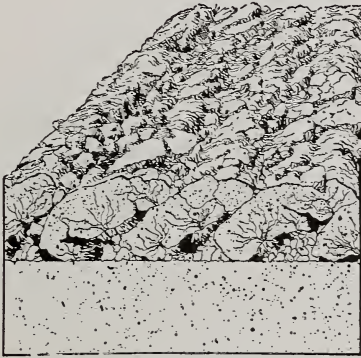
besides from experiments that even germinating seeds, which are most susceptible to a lack of air, can have their oxygen supply reduced to 1-32 of the normal amount in air before injury becomes manifest. Yet we know that in a puddled or compact soil plants will not do well. Putting these two things together we must conclude that not the roots of plants, but other things in the soil are so easily affected by a lack of oxygen. We know definitely what at least some of these things are. The bacteria which change organic nitrogen over into nitrates for plant uses must have a free supply of oxygen. The

ing and cultivating are to conserve moisture and to improve aeration in soils, their permanent effects are to assist in the rapid oxidation of the carbon and nitrogen in soils, which result in what King has termed a "dry puddling," and besides in a loss of that most important element, nitrogen. Such a destruction of the organic matter and derangement in the soil's structure must be followed by increasingly poorer aeration and a content of moisture which is either too great or too small for proper bacterial and root activities. Are we going to abandon tillage or any phase, partially or wholly, and

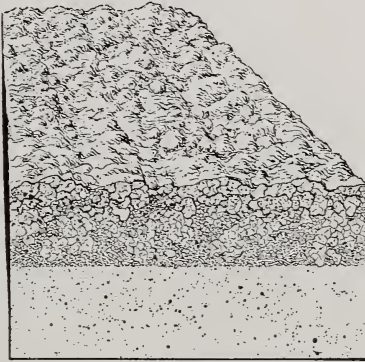
if so, what will take its place in the bestowal of the benefits?

In orchard land we must conserve the organic matter in one of two ways, either by supplementing green manuring and tillage with a mulch during the summer of manure, straw, leaves or any other efficient moisture conserver, or give up tillage altogether and keep the orchard soil mulched the year round. We may modify the last procedure by using it for a period of three years following by tillage one or two years, and then going back to the year round mulching system. In other words, we

and should give even better results. So far as cereals (not hoed) are concerned, of course our procedure must be different. Manifestly we cannot mulch certain grain crops without losing the use of part of the land. We must therefore employ quantities of organic matter to plow under which are so much larger than usual as to make up, so far as possible, for the rapid oxidation which tillage produces in such lands. Moreover, in fallowing such land we can, after plowing and cultivating, mulch the surface of the soil and leave it so until the time for



Undisked stubble plowed. Observe that the ground is turned up in lumps, that there are open spaces at the bottom of the furrow which prevent the close compactness of the lower portion of the turned furrow with the soil beneath.



Disked stubble plowed. The mulch formed by the disk harrow fills up the open spaces at the bottom of the furrow, thereby forming a close connection with the sub-surface.

are dealing with a general principle of organic matter conservation by a partial or complete mulching system which means a saving of moisture, a greater uniformity of temperature throughout the year, greater bacteriological activity, hence of a better supply of available plant food and of the use, instead of non-use, of the most valuable layer of the soil—the surface layer.

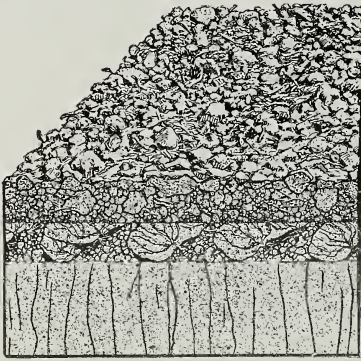
So far as other crops are concerned, we may use the mulching system in some and not in others. For example, in the case of hoed crops and small fruits, the same system can be used which is recommended for orchards,

seeding has arrived. It is my opinion that a system of deep plowing, heavy green manuring and mulching will not only maintain high yields in our grain fields, but that it can be made instrumental in increasing the yields on our misnamed “exhausted” soils.

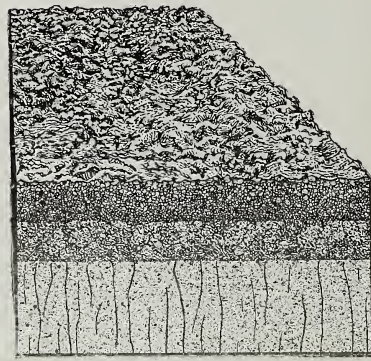
Wherever we can, by other means, maintain in good proportions, our organic matter supply and still employ tillage, that the old principles of tillage may still be regarded as sound and worthy of application; on the other hand, where organic matter wears out or oxidizes away faster, or as fast, as we can replace it, untold injury is

wrought by tillage operations. Then the principles of tillage and their application must be discarded, in whole or in part, depending upon the peculiarities of practical management which may be characteristic in specific cases. In orchard practice, particularly, but also in the vineyard, in the berry patch and in the truck patch, we shall have to resort to better methods of incorporating organic matter in the first place, and in the second place, of conserving with it the proper moisture conditions,

but in principle anything that will thoroughly cover the soil will bring about the advantages which are named above from such a practice. In the case of crops like our grain crops, undoubtedly other measures, such as the incorporation into the soil of very much larger quantities of organic matter than we would normally incorporate may have to be resorted to, but in any case, we cannot expect to grow grain and large crops, under ordinary soil conditions, without the incorporation



Plowed field, disked and harrowed. There is a deeper seed bed on the surface, but many hard clods and air spaces are in the bottom of the furrow.



Disked stubble plowed and disked before harrowing. Observe the compact condition of the soil, that the air spaces are completely filled up, and that the ground is in first-class condition.

the proper bacteriological conditions and the proper chemical and physical conditions essential to the maintenance of the soil's fertility.

The nature of the mulching material will vary considerably, and much experimenting may still be done with different kinds of cheap mulching materials that may be found to be effective,

of plenty of organic matter. It may prove feasible, even under the conditions of grain fields, to use the stubble and to use the straw as mulching material immediately following harvesting for the preservation of good conditions within the soil itself, until the following season.

THE NATURE AND CAUSE OF SOIL ACIDITY

How Disintegration and Weathering Produces Toxic Elements

E. TRUOG, Soil Chemist, University of Wisconsin, Madison, Wisconsin

SOIL acidity is believed to be the greatest immediate soil problem confronting the majority of the farmers in the eastern half of the United States. Farmers and scientists noticed long ago that soils well supplied with lime were usually much more productive than the acid ones. While some crops are not directly injured by an acid condition, others, including the most valuable legumes, are greatly affected. A long continued condition of

various combinations make up all the different things found on this earth. Iron, potassium, calcium, phosphorus, magnesium, sulphur, carbon, hydrogen, oxygen and nitrogen are elements. Practically all the elements are found in soils, some, of course, in very small amounts. The ten elements named are the ones which are found in plants and animals. One peculiar property of elements is that they will unite with each other and form different compounds



"Making Bread from Stones." Field of wheat on State Normal School Farm, Bowling Green, Ky., which shows result of raw limestone and phosphate treatment, after three failures before these were used.

soil acidity has numerous unfavorable effects on the fertility of the soil, many of which are still poorly understood and much less appreciated. The development by experiments of a clear understanding regarding the cause and nature of soil acidity is the first logical step in working out rational and profitable treatments for soil acidity as found under varying conditions of crops, soil and climate.

After years of experimentation scientists have found that soils are composed of eighty different elements, which by

and substances, such as wood, leather, sand, clay, etc. In explosions elements combine and react with tremendous vigor.

Another peculiar thing is that nearly all elements unite with oxygen, forming either acids or bases. Thus, phosphorus combines with oxygen and forms phosphoric acid; potassium with oxygen, forming potash, a basic substance; and calcium with oxygen, forming lime, which is another base. In the soil then, there are a large number of different acids and bases. Still another peculiar

thing is that acids and bases unite with each other and form neutral substances called salts. Common cooking salt is an example. Thus lime and phosphoric acid unite, forming a neutral salt, called calcium phosphate. The phosphorus in rock phosphate is in the form of calcium phosphate. If part of the calcium is removed from this phosphate, there is left acid phosphate, which is acid to different tests. Thus elements combine to form acids and bases, and the acids and bases unite to form neutral substances called salts.

The elements in the soil are combined in this way; thus the soil is largely made up of different kinds of salts. The salts in a soil are of many different kinds and have all sorts of colors and properties. Naturally less base in proportion to acid destroys the balance, and the soil is acid.

The cause of soil acidity was formerly attributed entirely to organic acids which arise from decomposing organic matter, such as manure and plants. The prevalence of acidity in many upland soils almost devoid of organic matter, however, could not be readily explained in this way, and recently the writer has been able to show that these soils remain acid even after the organic matter in them has been destroyed. The acidity in such soils is clearly due to mineral acids. In a consideration of the cause of soil acidity, acid soils may conveniently be divided into two classes, namely the poorly aerated and the well aerated. The poorly aerated will be considered in the following paragraph.

The poorly drained peat and muck soils make up the major portion of the poorly aerated acid soils. The excess of water prevents a thorough circulation of air into the soil, and under this condition considerable amounts of organic acids are formed, leaving an acid

condition. If the surrounding upland contains considerable limestone, the drainage and seepage water may bring in enough lime carbonate to neutralize the acid formed, leaving neutral or alkaline peat or muck soil. Acid peat and muck soils, after thorough drainage and cultivation, usually become less acid, due to the fact that soluble acids may leach out and the entrance of air makes possible the gradual decomposition of insoluble organic acids. In virgin clay and silt soils covered with prairie grass or hardwood timber, the return of dead grass and leaves furnishes a covering which prevents ready access of air; hence, organic acids may form and accumulate unless neutralized by lime carbonate naturally present in the soil. When this type of soil is brought under cultivation the organic acids decompose gradually and the acidity due to them disappears. In time, however, a new acidity, due to mineral acids, may be developed.

The cultivated upland soils make up the major portion of the well aerated acid soils. Thoroughly drained and cultivated lowland mineral soils, and even sandy virgin soils, also belong here. This class of acid soils is of far greater extent and importance than the class treated in the previous paragraph. The acidity, as previously stated, is due to mineral acids, and they are developed as follows:

The good aeration promoted by cultivation causes organic matter in the form of manure and crop residues to decompose rapidly. Under these conditions the usual organic acids causing acidity in poorly aerated soils not to accumulate, but decompose and form attacks the minerals of the soil—the salts—and as a result the basic parts go into solution, being removed not only by growing plants, but also to a much greater extent by the leaching

effect of the soil water that passes down through the soil after each rain. Nearly one-half of the rainwater that falls in the humid region passes down through the soil and finally emerges in the springs that feed the rivers and lakes. The data of several experimenters indicate that, on an average, about three to five hundred pounds of bases, principally lime, per acre, are annually leached out by this drainage water. The acid parts of the salts are usually much less soluble, hence the greater portions remain and produce an acid condition unless the soil contains lime carbonate or receives it artificially.

By a long continuance of these processes even soils that once contained considerable lime carbonate or are derived from limestone, may become acid. Practically all the soils of the eastern half of the United States will some day become acid through the process just explained. A few comparatively small areas receive lime carbonate in the drainage and seepage water from the surrounding upland, and hence are not becoming acid. The soils of the arid region are not leached to any marked extent and the bases made soluble, as just explained, accumulate, giving rise to strongly alkaline conditions.

The mineral matter in soils arises from the decomposition of rocks. All of us have seen stone quarries in which the different stages of rock decomposition or weathering are represented. On the surface is usually found a covering of soil darkened by the addition of organic matter from plant residues. Below this the soil is lighter in color and gradually takes on the shade of the parent rock farther below. A layer of rotten rock, partially weathered, usually intervenes between the soil and hard unaltered rock. The weathering

of the rocks and the formation of the soil in a case like this has probably taken thousands of years. If the surface soil is tested it may be found acid, even though the underlying rock be limestone. If the parent rock is sandstone it is almost certain that the soil will be acid. The weathering processes not only act on the rocks, but continue to act at an even much greater rate in the formed soil, and make the materials of the soil soluble and available for plant use; hence are absolutely essential to a fertile soil, though a considerable amount of bases not used by plants are lost by leaching.

The writer has been able to demonstrate with an experiment that soils become acid by the process of weathering, as explained. A sample of granite was thoroughly powdered and then tested and found to be non-acid. The powdered material was then treated and leached with large amounts of carbonated water, after which the material was found to be decidedly acid. This experiment illustrates the formation of acid soils by weathering. When an acid soil was treated in this way the acidity became greater.

The general development of acid soils over the greater portion of the humid region may raise the question as to whether or not there is danger at some far distant future date of exhausting the supply of limestone. There is no danger, since the bases that leach out are again deposited, pound for pound, in seas and lakes as limestone. The lime carbonate makes a complete cycle. Nature carries it from the field to the quarry, and it is man's duty to carry it from the quarry to the field in order that the soil may be kept in the highest state of productivity.

THE LIME REQUIREMENTS OF SOILS

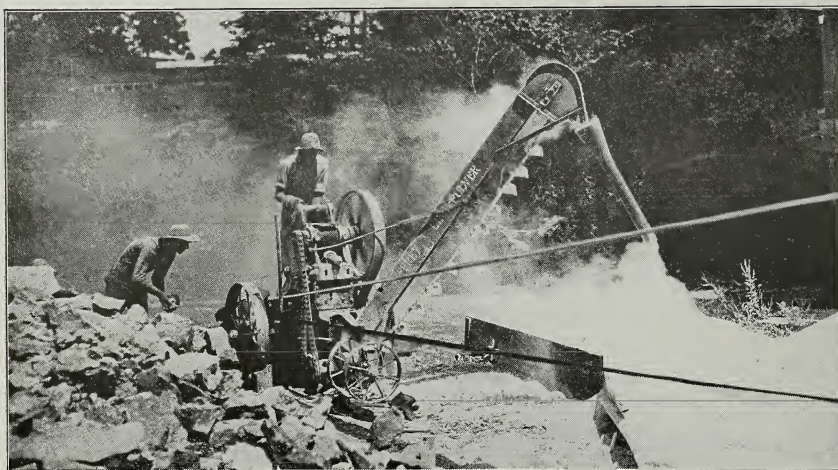
How Raw Ground Rock and Fertilizers Restore Fertility

JOSEPH E. BARKER, Agronomist, New York Agricultural Experiment Station, Geneva, N. Y.

“A LIMESTONE country is a rich country” is a proverb long accepted among American as well as European farmers; and the truth of the maxim is illustrated in many instances and many ways. There are within the United States certain large continuous areas of limestone land, regions in which the soil is derived from the disintegration and decomposition of limestone rock. These, because of their lasting fertility and consequent prosperity

count that these lands still bear up after two hundred years of exacting cultivation.

In New York State a section of country from Utica to Buffalo, varying in width from fifteen to thirty miles, constitutes the cream of the state, and is as large a continuous area of excellent land as can be found in the East. Throughout the region the glacial till contains limestone gravel and boulders from the Onondaga and Niagara for-



Grinding Limestone With a Portable Pulver.

of the farming populations, have become famous agricultural districts. Thus we have the Blue Grass region of eastern Kentucky and northeastern Missouri, on the whole one of the most renowned farming sections in the United States. Another example in question is the Shenandoah Valley of Virginia, which is not an ordinary river valley, but a fold in the earth between two mountain ranges. Extensive limestone beds constitute the parent rock of the valley soil, and it is on that ac-

mations. Here the soils are naturally adapted to alfalfa, and here is included the principal fruit-growing sections of the state.

In Ohio that region through which the Miami River flows is perhaps the most prosperous agricultural section, and has been described by some as the particular corner of the globe where man is found at his best. Here the character of the soil is largely influenced by phosphatic limestones. Those acquainted with farm lands in south-

eastern Ohio, outside the drift area, are familiar with the fact that almost every community, and frequently individual farms, furnish examples of the contrast between limestone and non-limestone soils, and that limestone lands are uniformly held in high esteem.

The excellence of limestone lands, of course, does not depend entirely upon the carbonates (limestone) which they now contain. Usually such soils are also well supplied with the mineral elements of fertility, and the phosphorus may be somewhat more available than

blown, the poor subsoil turned up by grading, will be found growing luxuriant crops of clovers, alfalfa, blue grass or other valuable crops which the adjoining fields will not produce unless similarly treated. This is an illustration of the value of limestone so forceful and convincing that it seems strange it has been so little heeded.

Why Lime Is Important.

Calcium and magnesium carbonates (limestone) are the natural soil compounds effective in neutralizing the



Applying Lime to the Soil.

in other soils by reason of its being present more largely in the form of calcium phosphate rather than in combination with iron and aluminum. Yet how very much is dependent upon the presence of lime carbonate itself is shown by the fact that the poorest soils can be changed over to limestone soils largely by the use of liberal applications of ground limestone. A most striking illustration of this fact is written all over the country, or wherever a limestone highway has been built. On either side of such roads for several feet, where the limestone dust has

acids constantly being formed in the soil by the decay of vegetation, the production of nitrates and in the addition of fertilizers or other foreign materials. The presence of a fair amount of lime carbonate is necessary to any normally fertile soil. Compared with other mineral compounds of the soil, lime carbonate is easily soluble, and this, together with the action of acids, has resulted, in the humid region, in its being almost or entirely leached out of all but natural limestone lands. Even the latter, under long cultivation, often respond to applications of lime-

stone. When lime becomes deficient in the soil a number of important things begin to go wrong. The clover disappears, the grasses thin out and nitrification becomes less active. The diminished supply of nitrogen and organic matter affects other crops, and they may even lack a sufficient ration of calcium and magnesium for plant food. Less organic matter, together with an acid reaction of the soil, causes poor physical condition; instead of having a loamy, friable texture, the soil becomes lifeless, is less easily cultivated and more susceptible to drought.

An even more serious, because usually overlooked, effect of a deficiency of lime in the soil is that the crops produced on such land may contain insufficient lime for the proper nourishment of livestock or even man. A liberal amount of lime is necessary to form the bones of growing animals, and especially for the production of milk and eggs. Casein, which makes milk white, is a proteid, having calcium as an essential constituent. The shells of eggs are about 98 percent lime carbonate, and the yolks and whites contain relatively large percentages of lime. One cause of abortion among dairy cows is an insufficient amount of lime or phosphorus for both mother and offspring, and the remedy often prescribed is to feed bone-meal. Many are the instances of cows being choked on a bone found in the pasture field, and it is a common experience to see them lick the whitewash from the mangers and stanchions.

Pigs on a ration deficient in lime salts will greedily crunch coal, ashes or anything containing lime; and if they do not get a sufficiency their bones will become so weak they cannot stand. Experiments have been conducted showing a great difference in the breaking strength of bones from pigs on a ration deficient in lime as compared

with those on a ration well supplied with that material. Cows, when fed a deficient lime ration, are known to draw upon their own bones for lime necessary to milk production. The extreme fondness of cows and chickens for alfalfa and its marked value in their rations is no doubt partly explained by the liberal amount of lime salts which it furnishes in addition to its high protein value. A ton of alfalfa hay contains calcium and magnesium equivalent to 190 pounds of limestone, while a ton of cornmeal or wheat contains these elements equivalent to only 6 or 8 pounds of limestone. It may be mentioned that certain medical researches have shown a relationship between a deficiency of lime in the system and tuberculosis.

Limestone Needed by Soils.

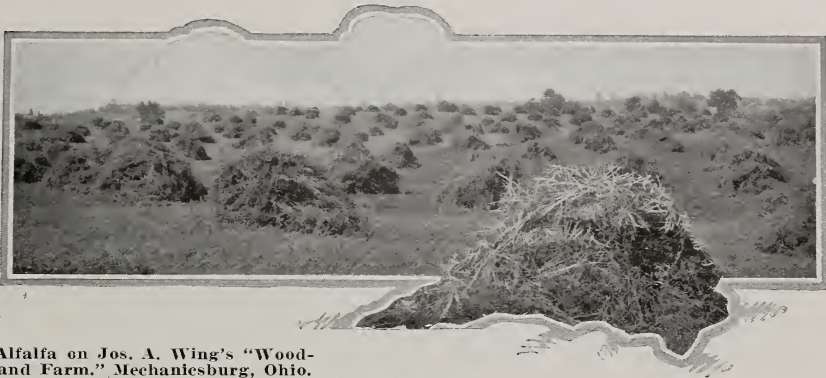
It is hardly correct to say that the amount of lime required by a soil depends upon the amount of acid present, for only a very small amount of acid is ever present in the free state; but the acids constantly being formed under natural conditions, and those introduced with fertilizers, remove the bases from the soil, chiefly calcium and magnesium. It is first the carbonate of these elements that are reduced; then they are extracted from their combination with the silicates. When this process has gone on long enough the soil remains constantly acid in reaction, and it is largely the extent to which the bases of the soil are reduced that determines the amount of limestone needed by the soil. Laboratory methods have now been devised which are capable of giving the lime requirement of any given sample of soil with a fair degree of accuracy.

In New York State the lime requirements of various types of soil vary from a few hundred pounds per acre

to ten tons or more, the determinations being for the surface seven inches, the plowed soil. From what the writer knows of soils in Ohio he may say that as great a range as this will be found in their lime requirements. If a soil is in need of lime, one ton of limestone per acre is probably as light an application as is advisable to apply. Where the lime requirement determinations indicate two to four tons, two tons per acre is usually a fair amount for one application; and in the general use of limestone, this is becoming a standard amount to apply at one time. However, in connection with the growing of alfalfa or other crops with which

a limestone outcrop are less in need of lime than the lower levels. Hill lands or the higher parts of fields are more in need of lime than the lower levels. Soils of heavy texture need more lime than those of lighter texture. Soils long cultivated need more lime than virgin soils.

When soils have once become to need lime, it is advisable to make an application about once in a rotation of three to six years. The amount of limestone a soil will annually use under good farming can be appreciated when it is understood that with a rotation of alfalfa, alfalfa, potatoes, wheat, 200 to 300 pounds nitrogen per acre annually



Alfalfa on Jos. A. Wing's "Woodland Farm." Mechanicsburg, Ohio.
Ground limestone, phosphorus and Manure Applied.

an abundance of lime is so important a factor, the landowner should find out the lime requirement of his soil and then plan to supply the full amount as soon as practicable. Where the requirement is above four tons per acre, it may not be possible to have good results with alfalfa until as much as four or five tons have been applied as an initial application.

Nearly all soils in eastern United States, unless derived in large part from limestone formations, are now in need of lime. Residual soils derived from sandstones, sandy or clay shales show high lime requirements. In glacial drift regions, soils lying south of

will be converted into nitric acid, requiring 700 to 1200 pounds of limestone to neutralize it. When to this is added the drafts made on the limestone by other acids and that lost in solution before combining with acid, two to four tons per acre for each rotation of three to six years are only a reasonable amount.

The landowner is often confused by the question of relative values of different forms of burned lime, various lime by-products and different grades of ground limestone. The problem would be greatly simplified if it were generally understood that, as a rule,

the natural raw limestone is the cheapest and best and that it need not be ground so very fine. The value of any lime product for agricultural use is best understood when stated in terms of its equivalent of pure limestone or calcium carbonate.

Lime and Fertilizers

While a liberal amount of lime in the soil is fundamental, there is a tendency to overemphasize its importance to the neglect of other important factors. Excepting on land extremely deficient in lime, an application of that material should be expected to yield results that

once in a rotation and lime applied at the time of preparing the land for corn. The first application was burned lime at the rate of one ton per acre; later applications were one ton of ground limestone per acre, making an average of one and one-half tons of ground limestone or its equivalent for each of the first two rotations. The test included the use of limestone in combination with various fertilizers, and also with barnyard manure.

The sum of the values of increase from **lime and acid phosphate**, when used on separate plots, has been \$38.58



Alfalfa on the Farm of The Wing Seed Company

are mild and lasting, rather than phenomenal and short-lived, and its use should be a part of a systematic scheme for increasing the phosphorus, organic matter and lime content of the soil.

Lime does not take the place of other fertilizers or manures, but supplements them and permits of their more efficient use. This is well illustrated in a report of twelve years' experiments at the Ohio Agricultural Experiment Station. The lime was used in a five-year rotation of corn, oats, wheat, clover, timothy. The test was carried out on each of five different fields each year, the land being used

per acre as an average of each five-year rotation, but when used together the increase has been worth \$40.83.

Lime and a combination of phosphorus and potassium, when used separately, have given a total increase worth \$49.15. When used **together** the value of increase has been \$54.28.

The total increase from **lime and complete fertilizer** used separately was \$57.19; used in **combination**, \$61.22.

Lime and manure (16 tons per acre in five years) used separately have produced increases worth \$77.08; when used on the same land the figure is \$88.53.

THE MILE-POSTS IN FERTILIZER USAGE

Foods That Crops Need to Return the Highest Yields

J. W. HENCEROTH, Soil Improvement Committee, Chicago, Illinois

IN the plants that grow in the gardens and fields, there are thirteen plant-food constituents taken up by the plants, namely, carbon dioxide, water, nitrogen, phosphoric acid, potash, lime, magnesium, sulphur, iron, calcium, silicon, manganese and sodium. The first nine of these are classed as necessary, because every plant must have them in the right proportion in order to live, grow and mature a crop of fruit. The last four are classed as unnecessary. The plants take them up because they are dissolved in the soil water, but so

Phosphoric acid is the plant-food that hastens maturity, causes the laying down of the fruit and improves the quality. I have known corn that had an abundance of phosphoric acid to ripen from ten days to two weeks earlier than corn on the same land that was not supplied with plenty of available phosphoric acid. The third plant-food, potash, assists in the laying down and transportation of the starch to the grain or fruit and gives strength or rigidity to the stalk.

In addition to the above named, every

THE PLANT-FOOD IN SOILS.

	Nitrogen.	Phos. Acid.	Potash.
Sandy.....	Poor.	Poor.	Poor.
Clay.....	Medium.	Medium, but frequently unavailable.	Medium, but frequently unavailable.
Humus or Muck.....	Abundant. This nitrogen largely unavailable.	Poor.	Very poor.

FOODS THE CROPS NEED.

	Nitrogen.	Phos. Acid.	Potash.
For Hay.....	Abundance.	Fair supply.	Fair supply.
For Grain.....	Fair Supply.	Abundance.	Fair supply.
For Roots.....	Good Supply.	Fair supply.	Abundance.

far as authorities know at the present time, they are not needed.

It suffices to treat of what are commonly called the three essential plant-foods, because they are most frequently deficient in the soils and are required in large amounts by the various farm crops, namely, nitrogen, phosphoric acid and potash. These are the plant-foods supplied in commercial fertilizers.

Nitrogen is the plant-food that gives the rich green color to the plants and produces stalk growth. In a field of corn, wheat or oats that is short or stunted, there is almost certain to be a deficiency of nitrogen in the soil of that field.

farmer and student of agriculture should know two facts—first, the relative amounts of these three essential plant-foods—nitrogen, phosphoric acid and potash in the principal soils; second, the relative amounts of these plant-foods needed by our crops. These facts are brought out clearly in the above table.

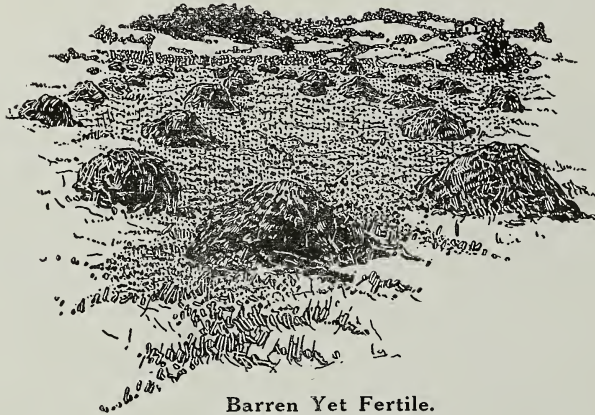
The above are fundamental facts that are known to be true of our soils and crops. How can these two facts be linked up by the farmer? Suppose he determines to grow wheat on a sandy soil. He first notices that wheat, being a grain crop, requires an abundance of phosphoric acid and a fair supply of

nitrogen and potash. A typical sandy soil, especially if it has been cropped for any length of time, is poor in all three essential plant-foods. In this case a complete fertilizer should be selected that analyzes high in available phosphoric acid and has a fair supply of nitrogen and potash.

The fertilizers for all soils should be balanced up to meet the particular requirements of the crop and to make up for the deficiencies in the soil, since all soils are more or less deficient in one or more of these three essential plant-foods.

pounds, 100, 300 or 400, until the amount is found that gives best results. Many of our most successful farmers are finding that the larger amounts of fertilizers are the most profitable.

Feeding crops is much like feeding livestock. Our showmen know that if the baby flesh is ever lost from the calf, pig or colt, it is an expensive process to get it back, and the young stock never mature into such splendid animals as they would have done had they been kept growing from the start. A generous feeder has the best livestock. Plenty of feed gives the calf a quick,



Barren Yet Fertile.

After securing all the information possible as to the best fertilizer for a particular soil crop, the farmer should then test it out on his own farm by leaving a few rows of corn or a strip of wheat or oats unfertilized. At harvest time the ground should be measured and the grain weighed to determine the difference both in increased yield and superiority in quality where the fertilizers have been used. After finding a fertilizer that suits the soil, then test out various amounts, say 150

sure start. Plenty of the right kind of plant-food gives our plants a running start, enables them to keep ahead of the weeds, helps them to resist disease and to mature their crops early.

These are all important, but the one we often lose sight of is the first, namely, giving the crops a quick start. The man who sees that his soils and crops are well supplied with the right kind of plant-food will have the earliest, best matured crops of highest quality.

FACTORS INFLUENCEING SOIL MANAGEMENT

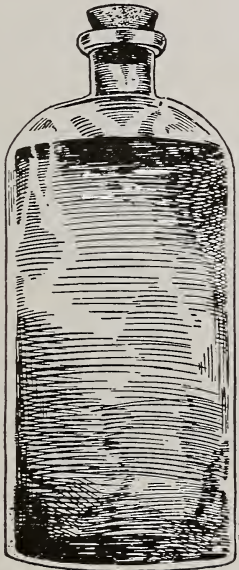
Six Positive Conditions That Join in Growing a Plant

E. O. FIPPIN, Professor of Soil Technology, Cornell University

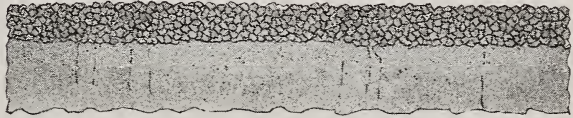
WHEN crops do not thrive we say "lack of fertility." That, however, gives no information as to why the crop fails. There may be any one or more of a half dozen reasons why the crop does not thrive, and each of those limitations may be the result of a dozen contributing causes. Truly the word fertility is a common mask of ignorance of the real causes of fer-

the conditions requisite for plant growth are in part supplied through the soil and, therefore, are dependent upon the character of the soil.

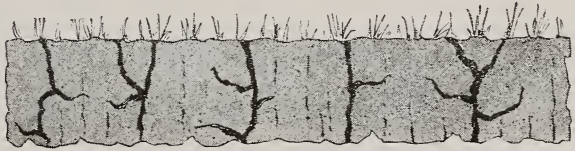
The rational starting point in the consideration of questions of soil fertility is, therefore, the plant itself—the conditions that are requisite for plant growth—all plants and not merely any particular individual. All plants agree



It took the water in the large bottle to produce the corn in the small. The dust mulch saves the water.



The dust mulch that holds the moisture and insures fine root development.



Moisture escaping in dry, cracked, soil. This could not happen under proper cultivation.

tility or lack of fertility—meaning by that, crop producing power.

No single factor can be named that is responsible for a fertile soil, nor for the lack of fertility. This is so because there are at least six positive conditions that join in the production of a plant. The lack or insufficiency of any one or more of these, results in no plant or in a poorly developed plant. Some of these conditions are met by the soil; some are independent of it. Most of

in having a certain few fundamental requisites. The quantity or character of these may differ for different plants, but in some form they must be present. By an examination of these with reference to the plant, it is possible to determine the functions of the soil in plant production, and from a further consideration of its normal character and properties determine the type of changes that may be required to enable the soil to fulfill its proper functions.

The common practices of soil management have value only in so far as they contribute to these desired changes in the functional operation of the soil. They are intelligent and economical only in so far as they are accurately selected and applied, because they are effective and are the most economical

means to secure the desired end, which is larger crop growth.

The essential conditions for plant growth are six positive factors and a group of negative factors. They are food, moisture, light, heat, oxygen and mechanical support for the positive factors; and freedom from any sort of interfering conditions on the negative side, such as destruction by insects or animals, injury due to disease organisms or interference due to toxic or poisonous conditions. The correct adjustment of these factors for any particular plant results in full normal growth.

A careful examination of these conditions will reveal that some of them are supplied in part or in whole by the soil. Some are partially or wholly independent of the soil. As a matter of fact, every one of these requisite conditions, with the possible exception of light, is partially or wholly conditional by the soil. Consequently, soil management is to be interpreted in terms of these conditions.

Of the ten elements of essential plant food, the soil supplies six direct—potassium, sulfur, phosphorus, calcium, magnesium and iron, which seldom make up over three to five percent of the plant. It supplies one indirectly—nitrogen—which forms from one to four percent of the plant, but derives that supply ultimately from the air above the soil. The other three are supplied from the air and from water, namely, carbon, which makes up about 50 percent of the dry plant, and oxygen and hydrogen, that make up 45 percent of the plant. Therefore, only 5 to 10 percent of the dry substances of the plant are derived from the soil. The remainder is air and water bottled up by sunshine.

For farm and garden crops practically all the water is taken in from

the soil by the roots. Hence the supply and availability of the water in the soil is a limiting condition. All parts of the plant within the soil derive their heat supply from the soil, and since this is one form of energy the temperature of the soil is of importance. Light may be eliminated from consideration here. Oxygen, commonly designated as air, which is one-fifth free oxygen, is just as essential to the roots of plants and to the lower forms of plants—bacteria and fungi—as it is to animals. All the cultivated crops require this in free form. Therefore, the ventilation of the soil is of prime concern. Mechanical support is obviously necessary for the larger crops in nature.

The management must be directed to adjust the properties and conditions of the soil to meet the needs of plants. The soil is one of the media in which plants grow. It has certain normal properties by means of which it carries out these functions.

First, the soil is a porous mass. Within these pores water is retained and air should be distributed. The volume, size and distribution of those pores determine the relative proportion of those two materials. In a coarse, open soil the water supply is likely to be short and the air supply long. In a fine, compact soil the water supply is long and the air supply is short. Between these extremes is the desirable medium. The immediate object of tillage is to change either by enlarging or reducing the pore space in the soil and through this change a variety of effects is produced. Dependent upon the amount and proportion of water and air in the soil pores is a long line of processes—the penetration of roots, the activity of micro-organisms, the temperature of the soil, the drainage conditions, the availability of plant-food and other things. Second, the soil out

of the mass and the particles—supplies the mineral elements of food. This is a matter of solution, and anything that affects that process, thereby influences the need for fertilizers. Third, in the pores of the soil the decay of organic matter and the fixation and elaboration of nitrogen into available forms should go in. It is affected by the same conditions that affect the development of roots.

On the other hand, by a long period of practice a few methods of treatment have been worked out that have proved their capacity under certain conditions to make the soil more productive. They do this by effecting certain definite changes in line with the need of plants. These treatments are drainage, irrigation, liming, the addition of organic matter, rotation, inoculation, tillage and the use of fertilizers. But these treatments, while they have a primary effect, do not have a single effect. Each have a number of secondary effects, and it sometimes happens that the benefit may come from the secondary instead of the primary effect of the treatment. It sometimes happens that the same treatment produces opposite effects on different soils. Hence the danger of laying down fixed rules for the handling of all soils.

The first effect of drainage is to remove the surplus water and make the soil firm. It also introduces ventilation, reduces heaving in cold climates, deepens root penetration, makes the soil more warm, increases the availability of plant-food, and effects a number of other beneficial changes. Lime corrects acidity. It also aids in the fixation and elaboration of nitrogen and may release phosphoric acid and potassium. Organic matter adds plant-food, but it also releases carbonic and organic acids that attack the soil particles. It affords a medium for the growth of use-

ful soil organisms. It is the primary storehouse of combined soil nitrogen. It brings about important physical changes in the structure of the soil, its water capacity and perhaps its temperature.

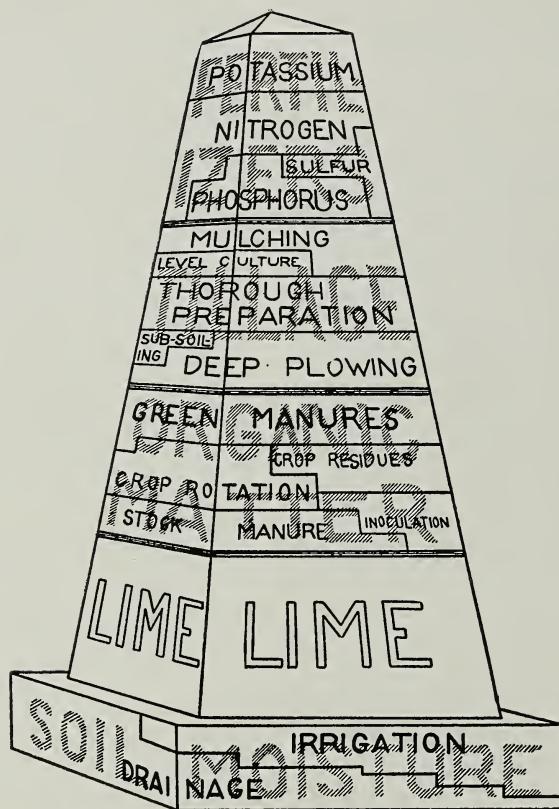
Fertilizers have the primary function to supply available plant-food—nitrogen, phosphorus and potassium being usually thought of in this connection. But of the last two the soil already contains many times as much as annual crops use, especially when a three foot section is made the basis of calculation. Here, too, there may be important secondary effects. Sodium nitrate corrects acidity. In the form of carbonate it may also puddle the soil. It may release potassium in the same manner as lime. Further, in a soil in bad physical condition a fertilizer may be of small benefit, because conditions are not favorable for the growth of plants in many other directions than the food supply.

It therefore appears that the methods of treating the soil to make it more favorable for plant growth in the light of the fundamental factors enumerated at the outset, should be related in a systematic way to get the largest benefits from each and all of them and from the natural properties of the soil. Inspection of any particular piece of land should proceed in a definite order, and the necessary treatments applied in so far as they may be needed.

First of all, the water supply of the system is the foundation. Unless it is adjusted within certain limits all other conditions are of no value. This may mean irrigation or drainage or only wise tillage and mulching. Next the chemical balance should be looked after. This generally means loading up the basic side that requires lime. Third, the organic matter should be present in moderate amounts to supply nitrogen

and give the other effects. This may mean the use of stock manure or green manure. It always requires the wise handling of the crop residues, the roots and stubble. Here the use of rotation, the legumes and inoculation come in as a contributing factor.

eliminate negative or interfering conditions mentioned at the outset. If the desired results are not secured, they may be supplemented by fertilizer as the conditions may indicate the need. In this system fertilizers have their highest possible efficiency.



This diagram was prepared by the Department of Soils, New York State College of Agriculture, Cornell University. It shows what they regard as the essential conditions for a fertile soil. Each tier is made up of the farm practices used to regulate the soil condition represented also on the diagram. Lime is one of the important factors in soil fertility.

These four groups of treatments or adjustments are fundamental to efficient soil management. They should be applied so as to form three feet of efficiently functioning soil. When taken with the normal character of soil they will usually produce fair to good yields of crops. They are the basis of the efficient use of fertilizers. Taken together, they will usually prevent or

Such a scheme of soil management is the foundation of good farming and the permanent and economical maintenance of the productive capacity of the soil. When the word fertility is used to mean this correct adjustment it has a definite application, and the waste basket is largely emptied of its content of loose verbal usage and still more loose soil management practice.

ESSENTIAL CONSIDERATIONS OF GOOD TILTH

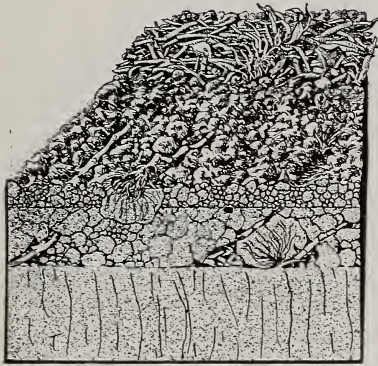
Pulverizing Alone Is Not Sufficient to Induce Good Yields

FIRMAN E. BEAR, Department of Soils, West Virginia University

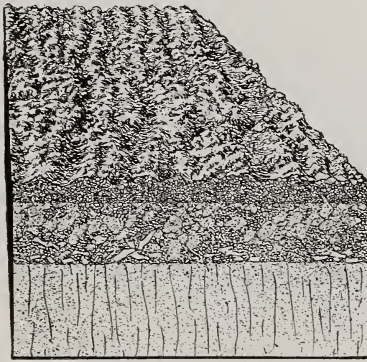
“**T**IS agreed that all the following materials contribute in some manner to the increase of plants, but 'tis disputed to which of them is that increase or food: nitre, water, air, fire or earth.”

A review of all the evidence available indicates that “Too much nitre corrodes a plant; too much water drowns it; too much air dries the roots of it; too much heat burns it; but too much earth a plant can never have unless it be therein wholly buried.

art of agriculture of his day. The science of agriculture was as yet only in its infancy. Tull's statements will not admit of too careful scrutiny in the light of modern science, but in so far as many of the practices suggested are concerned, “Horse Hoeing Husbandry” compares very favorably with the columns of the agricultural press of today. A careful study of the older agricultural literature reveals the fact that many of the best modern practices are very similar to those in use two



Field plowed and harrowed with an ordinary peg-tooth harrow. The stalks interfere with cultivation.



Field showing disked stubble plowed, disked and harrowed. Can you imagine a better seed bed for the planting of corn or any grain?

“It has been often observed that when part of a ground has been better tilled than the rest, and the whole ground constantly managed alike afterwards for six or seven years successively, this part that was once better tilled always produced a better crop than the rest, and the difference remained very visible every harvest.”

Jethro Tull was an enthusiast on tillage. His book on “Horse Hoeing Husbandry,” written in 1733, is one of the agricultural classics. In it he outlined the best practices known in the

centuries ago, and differ from them mostly in the implements employed rather than the results obtained.

To Jethro Tull tillage was nothing more than a scheme by which particles of earth were gotten into such a fine state of division as to permit of their being readily “absorbed through the pores of the roots.” In the glossary, Tull defines roots as the “guts” of the plants. The soil particles entered the roots as such, and were there digested and changed into materials which could be used in building plant tissue. How-

ever much Tull's science was at fault, his practice brought good results. In fact, he proved that large crops could be grown year after year on the same field if the soil was well cultivated and the crops were put in rows so that thorough intertillage was possible.

Experiments conducted by many investigators since the time of Jethro Tull have served to explain why tillage is so effective if properly done. But more than this, these investigations have given us the clue to a more rational system of maintaining soils in a condition in which they may be most effectively tilled.

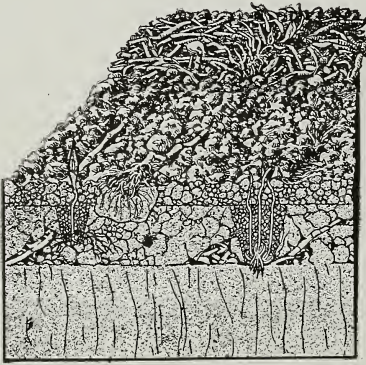
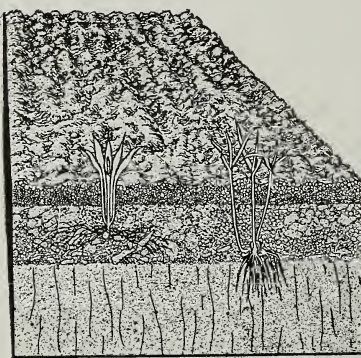


Illustration showing field planted with corn and small grain. The farmer is never certain of his crop with such a seed bed.



Field shown with corn and small grain planted. The ground is in perfect condition for the reception of the seed.

Thorough tillage at the right time and in the right way is not only one of the most effective means of increasing the productivity of a soil, but is, if continued, one of the most effective means of reducing a soil to the point of exhaustion. The word tillage is too limited in its scope to satisfy the requirements of modern scientific farmers. Something more than merely pulverizing the soil is necessary if it is to continue to produce heavy yields indefinitely. It must be remembered that these same acres which we are farming today will probably be under cultivation one thousand years from today,

and at that time the burden of the increased population will make it necessary that every acre produce more rather than less. Something more than mere tillage is necessary if the same amount of labor will suffice each year to produce as large or larger yields as were produced the year previous. Not only must a soil be well tilled, but it must be so managed that tillage is effective.

Tilth is a word which implies tillage and yet has a much broader significance. To say that a soil is in good tilth means not only that it has been well tilled, but also that the soil pos-

sesses certain qualities which insure that the minimum amount of tillage will be effective and that, with favorable weather conditions, a good crop is assured.

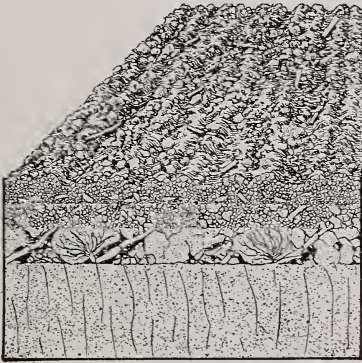
To keep a soil in good tilth certain fundamental requirements must be kept in mind. In a well kept garden one marvels at the ease with which the soil can be put into condition for garden crops. The condition of the soil by which this is possible is largely produced by the heavy applications of manure annually. Garden soils are not only easily tilled, but they are abnormally productive as compared to the

same type of soil in the field adjacent. It seems evident, therefore, that if one is to maintain the soil in condition wherein it can be prepared for crops with the minimum amount of labor, and where it will continue to produce crops year after year effectively, organic matter in some form must be recognized as a fundamental necessity.

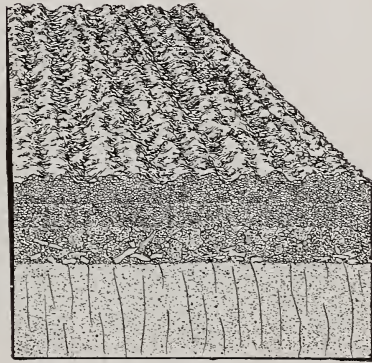
New ground soils, as a rule, are very loose and friable, but the same soil type, after years of farming by someone who is more or less indifferent to making any special effort to replace that which has been used up in the

effective soil particle. Under such conditions good tilth is impossible. The removal of the water by means of drains usually shows an effect the first year. Some soils are much more slowly remedied, but sooner or later the free passage of air and water is effected and the tilth of the soil is improved.

There are also stiff clay soils which may contain fair amounts of organic matter and even be fairly well drained, and yet when plowed the soil has a tendency to turn up in clods which can scarcely be broken with the ordinary tillage operations. The margin of time



Field disked after plowing. This is a common practice among farmers. It does not remedy the bed condition at bottom of the seed bed.



Disked cornstalk field disked and harrowed after plowing. This leaves the ground in perfect condition for the crop.

soil, becomes much more difficult to manage. However, virgin soils are not always in good tilth. There are certain conditions which the farmer often meets even in new soil which requires more than organic matter. Two conditions will be mentioned.

If for some reason, either because of impervious underlying strata or because of too slight differences in the level of the soil and its drainage outlet, the water is not permitted to run through the soil readily, the soil has a tendency to "run together." This "running together" is due to the breaking down of the soil aggregates, so that each individual particle becomes an ef-

fective soil particle. Under such conditions good tilth is impossible. The removal of the water by means of drains usually shows an effect the first year. Some soils are much more slowly remedied, but sooner or later the free passage of air and water is effected and the tilth of the soil is improved.

There are also stiff clay soils which may contain fair amounts of organic matter and even be fairly well drained, and yet when plowed the soil has a tendency to turn up in clods which can scarcely be broken with the ordinary tillage operations. The margin of time

between being too wet and too dry is so small that it is impossible often to plan the work so as to reach these areas at the time to get the soil turned over in the proper condition. Undoubtedly large amounts of organic matter would aid in overcoming this condition, but the amount required is such as to tax the farmer rather seriously to supply it. With such soils effective good tilth may be secured by winter or early spring plowing, in order that the soil may be subjected to the action of freezing and thawing. Soils which are difficult to manage may often thus be put in condition where tillage is very effective.

DETERMINING SOIL NEEDS IN THE LABORATORY

Tests That Show the Relative Deficiency in Plant Foods

G. S. FRAPS, Soil Chemist, Texas Experiment Station, College Station, Texas

IF the deficiencies of soils in plant food are known, they can easily be supplied; however, unfavorable climatical conditions, bad physical conditions and unsuitable locations are difficulties much less easily overcome, but it is a comparatively easy matter to add the plant food needed for a deficient soil.

The time will hardly come when the chemist in his laboratory will make the analysis of a soil and then write prescriptions for plant food for various crops. The soil itself is a laboratory, where a large number of chemical changes occur, some of which prepare the inert plant food for the use of the plants. The quantity of plant food prepared in this way will depend upon a variety of factors, including the temperature, the moisture of the soil and other constituents which are present. The plant food prepared in the soil will vary from year to year and from season to season. The chemist cannot, in a few hours, pass through in the laboratory the processes of the soil, which takes the several months of the period of plant growth.

All that the chemist can do at present is to study the relative deficiencies of the plant foods present in the soil. He can ascertain whether phosphoric acid, potash or nitrogen are deficient to the greatest extent, and which of these will become deficient first, under ordinary soil conditions. He can then judge as to which plant foods are needed and which should be supplied. But the amounts and combinations which should be applied must be determined by field experiments. In other words, the chemical analysis enables us to apply the results of fertilizer tests show-

ing the quantities of fertilizer needed for the best results on some soils of similar characteristics. The analysis in itself does not show the quantity of fertilizer which would be profitable.

A number of difficulties are encountered in applying the results secured in the laboratory to the field, and judging the fertilizer to be applied. Two important conditions are the depth of the soil and the character of the climate or season. The depth to which the plant roots go in feeding determines to a large extent the quantity of plant food which the plant will secure. This varies with different plants and with different soils. It is clear that where the roots go to the depth of eight inches the plant may secure only two-thirds as much plant food as where they go to a depth of twelve inches.

Climatic or seasoned conditions are important. Under favorable conditions of moisture and temperature the soil will produce more than where the conditions are less favorable. In other words, climatic conditions exert the controlling influence, and seasonal conditions may modify the deficiency of the soil.

At the Texas Experiment Station, the relation of the analysis of the soil to its yield in the field is being studied by means of chemical analysis, pot tests upon small amounts of soil, and cooperative fertilizer experiments with farmers in different parts of the state.

The pot tests show that the need of the soil for phosphoric acid is related to the active phosphoric acid in the soil, that the needs of the soil for nitrogen is related to the total nitrogen in the soil, and that the needs of the soil

for potash are related to the active potash of the soil. We have also drawn tables in which the quantity of plant food withdrawn by the crops in the pot experiments is tabulated with reference to the chemical analysis of the soil. These relations are expressed in bushels of corn per acre. Thus, a soil containing from 10 to 20 parts per million of active phosphoric acid has a corn possibility of twelve bushels per acre from phosphoric acid. One containing from 50 to 100 parts per million of active potash has a corn possibility of 37 bushels from potash, and one containing from .04 to .06 percent total nitrogen has a

we will secure still better results when we have learned the characteristics of the different soil types, which may require somewhat different standards of interpretation. This applies particularly to peat soils, highly calcareous soils and to some other abnormal soils, particularly those which are composed largely of oxide of iron.

We must always remember that the quantity of plant food in the soil is only one of the conditions of plant growth, and not always the controlling factor. Climatic conditions may be such that the production of 25 bushels of corn per acre is a good yield. Under



Applying Organic Matter to the Soil.

corn possibility of 18 bushels per acre from nitrogen. These tables are presented in full in Bulletin No. 161 of the Texas Experiment Station.

These figures do not represent the actual production of the soil in the field, but show the relation between the pot experiments and the chemical analyses. There is a decided variation between the individual soil and the average results and we are studying these further. The figures are intended to show the relative deficiencies of various soils.

I am satisfied that this method gives excellent results for ascertaining the needs of the soil for plant food, and

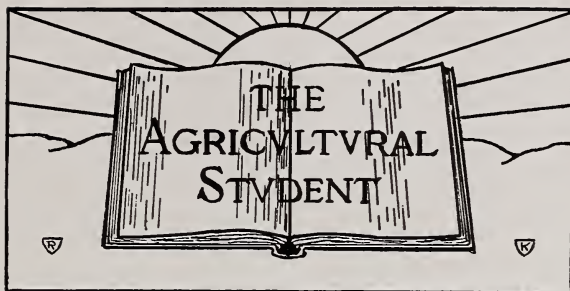
such conditions, a soil which supplies enough potash for 50 bushels would not be deficient. If, however, the conditions were more favorable, so that the corn possibility under the climatic conditions was 50 bushels per acre, then the soil would be deficient in nitrogen. Thus we see that deficiency is a relative term, and depends upon the conditions with which the soil is surrounded. The physical character of the soil itself may be one of the controlling conditions, for the soil may not retain more than enough water to make 20 bushels of corn per acre. Another soil, with more favorable physical conditions and

a better retentive power for moisture, may retain enough moisture for 50 bushels. Under these conditions, with the same amount of active plant food, one soil might be deficient and the other not deficient. In one case the moisture would be the controlling condition, and the other case the amount of plant food.

There are other methods for studying the plant food of the soil, such as determining the total phosphoric acid and

the total potash, and for determining that soluble in strong acid, but these have more to do with the wearing qualities of the soil and its ability to maintain its fertility than to its immediate needs or plant food. The use of the dilute acids so as to secure the active plant food appears to be the best method for ascertaining the immediate needs of the soil for that food.





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COLUMBUS, OHIO, JANUARY, 1916.

EDITORIAL

The war's effect on the fertilizer industry has been a favorite subject upon which much speculation has been made and a great mass of material written, especially in the newspapers of this country. The supply of raw products has been materially affected, and fertilizer prices per ton have risen several dollars in many cases. Writers have proceeded to speculate and estimate the effects upon American agriculture of the decreased consumption that will result because of conditions this year.

Such writings are predicated upon speculation and in some cases upon conditions that will probably not be, this year or any other year. There is no reason to believe that the northern

farmers will decrease their consumption of fertilizers because of the higher prices. In fact, on the basis of applications per acre, the increased prices being charged are very small. A 2-10-1 combination that sold to the farmer in 1914 for around \$23 per ton, is now selling at about \$27.50 per ton. On the basis of 200 pound applications per acre, the increase in price is only 45 cents per acre. A one bushel increase in corn yield will take care of this extra expense.

Farmers will do well to look to the experiment stations and agricultural colleges for their information as to the value of fertilizers, rather than to newspaper reports. It isn't a time for farmers now to use "snap judgment," based upon some item regarding the "serious-

ness" of the situation in the fertilizer industry. Instead, the increase in price for fertilizers should be considered along with the effects that will result on the maturity, quality, yield and market value of the crop and the fertility of the soil if fertilizers are used, and if they are not used. In the South last year, at the planting season, cotton was selling at 6 cents per pound, and as a result many growers cut down the amounts of fertilizers used. It was expensive economy, for at the time of maturity the price of cotton was back again to 13 cents, but the decreased yields were 32 percent. The decrease in acreage was only 14 per cent, and the season a normal one.

The Ohio Experiment Station reports should be studied by farmers of the Buckeye State who want reliable information on the amounts of fertilizers to use on their crops. Especial attention should be called to their experiments, which tell how to make manure more valuable. The increasing prices of farm products and the increasing demand for more products each year, make the matter of soil fertility one that should be seriously considered. Bumper crops from virgin acres are rapidly passing. We must return to the soil plant-food if we hope to maintain and speed up its crop producing qualities.

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Statistics taken from the "Work and Expenditures of the Agricultural Experiment Stations"

OHIO LEADS THEM ALL. during the fiscal year ended June 13, 1914,

shows the Ohio Station has 86 persons on its staff. Of these, 48 have degrees, although at least a third of the others have attended college, but were not graduated. In comparison with the numbers employed at other stations, Ohio can claim a decided superiority. The

first five states in order of the numbers on the staff are as follows:

Station.	Staff Members.	Instructors.
California	100	71
Illinois	94	65
Wisconsin	92	61
Minnesota	89	50
Ohio	74	..

From this table it will be seen that Ohio has more on the staff than any other station, on the basis of those whose time is devoted entirely to station work. Georgia is the only other state having the college of agriculture and the experiment station separated, although some states have more than one station. Many of the stations have substations, like our own state, however. Only a few states have two agricultural colleges.

There are now within the United States 62 experiment stations. In all these stations there are 1852 employes, of which 4.02 percent are in Ohio (1914). Hence, our State has 2.48 times the average staff.

When appropriations are considered, Ohio again is in the lead. The first five states in order of their total appropriations are as follows:

Ohio	\$481,418.72
Minnesota	396,068.54
Indiana	315,363.20
Illinois	298,620.56
Kentucky	258,753.93

During the year \$5,164,687.96 was expended in the 60 experiment stations. Hence, Ohio received 9.32 percent, or 5.64 times the average appropriation.

Regarding the publications, Ohio is far in the lead, having 85,000 names on the mailing list. Michigan is second with 65,000 and New York (Geneva) third with 47,000. There are 1,049,339 names on the total mailing lists. Hence, Ohio has 6.86 percent, or 4.25 times the average.

A warning to American farmers was issued recently by Secretary of Agriculture Houston, who is alarmed over the shortage of potash and the probable effect on the crop production. Importations of potash have been suspended as one result of the war, and the domestic supply is next to nothing. Potash is indispensable in the preparation of commercial fertilizer, and although the government is now making investigations with a view to encouraging domestic production, it will be a long time before potash will be produced here on a commercial scale.

"In view of the conditions existing," says Mr Houston, "it is important that all fertilizing materials on the farm, especially those collecting potash, should be conserved. The fertilizer ingredients already existing in the soil should be utilized and developed to the fullest extent. A great deal can be accomplished by deep plowing, constant cultivation and thorough tillage, and there should be a proper system of rotation."

Economic use of barnyard manure is one suggestion that stands out in bold relief to him who realizes the seriousness of the potash shortage. A ton of manure contains about thirty pounds of three essential plant-food elements, potash, nitrogen and phosphorus. The coarser portion of the manure, when worked into the soil, decays and creates gases which make dormant elements available. The organic portion is finally resolved into humus. Dean Vivian states that more soils are suffering for the lack of humus than from anything else.

Utilization of all available barnyard manure will prove a partial solution of the problem created by the shortage of potash, provided it is properly done.

When manure is spread by hand too much is applied in some spots, too little in others. When the application is too heavy it conduces to stalk growth at the expense of the grain, and the ripening of the plant is uneven. Moreover, the supply does not go far enough. Only by using a mechanical spreader can the farmer get the even distribution that is necessary. It has been thoroughly demonstrated by experiments that crop production is materially increased where the manure is applied with a spreader and, of course, it is obvious that a given quantity will cover a larger area than when spread by hand.

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It has been estimated that close to 50 percent of the fertilizing value of all the manure produced on the farms of the United States is annually wasted. This means a yearly loss of over one billion dollars—a tremendous sum. It is not possible to save all this waste, but at least half of it, and more, can be saved if proper precautions are taken. Just what this means to each farmer may be judged from the following figures representing the approximate value of the manure per farm animal per year, as determined by the Michigan Experiment Station: cow, \$29.50; horse, 23.70; sheep, 4.19; hog, \$2.25; and 100 hens, \$6.90.

These manure values undoubtedly seem high to farmers in the Middle West, where practically no commercial fertilizers are used, but to those of the East and South they no doubt appear to be conservative. While the farms in our territory are by no means worn out, there are very few that would not be greatly improved in producing capacity by the addition of more barnyard manure. and the great majority would yield 50 percent larger crops were they

more heavily manured. This being the case, the conservation of the barnyard manure is self-evidently a matter of importance.

Approximately half of the elements of fertility or plant-food in farm manure is found in the urine, and when mixed manure is left in the barnyard for any length of time, anyone knows what becomes of the liquid part of it. It is leached out, soaks into the ground in the barnyard or runs away. In either event it is lost so far as the farm is concerned. At the New York (Cornell) Experiment Station it was found that when manure is left in a pile in the barnyard, exposed to the elements for six spring and summer months, horse manure lost 57 percent of its gross weight and cow manure 49 percent. In terms of plant-food, this means a loss of 65 percent for horse manure and of 32 percent for cow manure.

The question arises, what can the farmer do to avoid such losses? We have seen that it is quite possible to avoid half of the usual losses. This may be accomplished in one of several ways: First, whenever possible, the manure should be hauled direct from the stable to the field as soon as produced. Second, the liquid excrement may to a large extent be preserved by the free use of bedding, oat straw being the best absorbent of the common straws. Experiments conducted at the Michigan station show that 100 pounds of oat straw will retain 285 pounds of liquid excrement after it has been in

contact with the liquid for 24 hours. Forest leaves are equally valuable for this purpose, and sawdust will absorb 435 pounds of liquid per 100 pounds. Peat is the most valuable absorbent known, being capable of absorbing six times its own weight of liquid. Still another way is to provide a cistern into which it may flow from the gutter behind the stock. One may also build a manure shed with a concrete floor, same to be used when it is impracticable to haul the manure direct to the fields. Laying a concrete floor over the feed lot, while expensive, is practicable, especially in sections where gravel is plentiful. It is for the individual farmer to consider which method to employ to reduce the immense losses of valuable plant-food that are sustained annually under present methods.

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For the etchings showing manure spreaders in operation we are indebted to The New Idea Spreader **CREDITS.** Co., of Coldwater, Ohio; the cuts showing liming operations, The Jeffrey Manufacturing Co., Columbus; the alfalfa scene of The Wing Seed Co., and the soil pyramid, The Scioto Lime Co., Cleveland; and to The International Harvester Co., Chicago, for the tillage scenes.

We are also indebted to Dean Alfred Vivian and Myron Bachtell of the extension department for suggestions and aid in preparing the subject matter presented in this number.





RAY FIFE, '17

THIS is one of the most difficult subjects in elementary and secondary agriculture, but at the same time offers an opportunity for many helpful and suggestive experiments which require simple and inexpensive apparatus. Such exercises as: Collection of types of soils, determination of differences in soil of different depths and many others can be profitably given. In the study of commercial fertilizers, samples can often be secured from the different companies producing them.

LESSON I.

Origin and Formation of Soil.

1. What is soil?

2. How soils are derived?

(a) By decomposition and disintegration of rocks.

3. Agencies of formation.

(a) Temperature changes.

(b) Atmospheric influences.

(c) Glacial action.

(d) Action of water.

(e) The work of animals.

(f) The work of plants.

Classification and Composition of Soils.

1. Soils are classed as peat, muck, clay, loam, sand and gravel.

Pupils should collect and classify the soils of the locality.

2. Discuss the relative value of each class for agricultural purposes.

3. Discuss the effects which the soils

of a locality have, with regard to the kind of crops grown.

4. Discuss effects of tillage, drainage, liming, freezing and thawing, and humus in changing the structure of the soil.

Water in the Soil.

1. The amount of water in the soil and in green plants.

2. Discuss loss of water from the soil by evaporation and percolation.

3. Discuss means of preventing the loss of water from the soil.

(a) By keeping down weeds.

(b) By increasing the amount of humus in the soil.

(c) By tillage.

Note the effect of mulching in reducing the loss of water through evaporation. How establish a mulch?

Air in the Soil.

1. Note necessity for air in the soil, especially in the growth of bacteria.

2. Discuss means of securing a free circulation of soil air.

(a) By lowering the water level of the soil through drainage.

(b) By cultivation of the soil.

Improving Soils.

1. Kinds of soil improvement.

(a) Physical condition.

(b) In chemical composition and food yielding power.

(c) In moisture retaining power.

(d) In bacteria or germ life.

Fertility of Soil.

(a) Rotation of crops.

Define crop rotation.

Note the evils of one crop farming. Depleted soils, hence constantly decreasing yields; poor distribution of labor during the year; better opportunity for weeds and insects to thrive; rush period in marketing. Note some farm of the vicinity which has practiced one crop farming. Note that a proper rotation of crops aids in keeping the soil in a high state of fertility after an

indefinite period. The soils of Europe are fertile after centuries of cultivation. Note that for rotation purposes crops are divided into three classes: grain crops, grass crops and cultivated crops. On account of differences in soils, markets, etc., the same rotation will not apply to all farms.

(b) Use of manures.

Note that Ohio suffers a loss estimated at \$25,000,000 through the waste of farm manures.

(c) Use of commercial fertilizers.

Much valuable material concerning

the use of commercial fertilizers can be secured from the Soil Improvement Committee, 916-917 Postal Telegraph Bldg., Chicago, Ill.

(d) Cultivation.

Note that cultivation improves the soil by improving the physical condition and by increasing its power of retaining moisture. Bulletins of the U. S. Department of Agriculture, Ohio Experiment Station and Agricultural Extension Department of Ohio State University will be found to be valuable in supplementing the work of the text.



THE INFLUENCE OF GLACIATION ON AGRICULTURE

A. R. WHITSON, University of Wisconsin, Madison, Wis.

AMONG the wonderful things that have happened to the earth during the ages of its history, as read by the geologist, none are more wonderful than the glacial periods. Everybody who has seen streams on hillsides realizes that if their erosion has been in progress during the thousands and millions of years, as claimed by the geologist, they have undoubtedly produced the changes in topography we now find in hills and mountains. But it is hard to believe the geologist's story that at several widely separated periods ice sheets thousands of feet thick have formed in Central Canada and have flowed down across the northern part of the United States, grinding off hilltops, filling up valleys, changing courses of rivers and leaving thousands of small lakes scattered over the area it covered. A careful study of the effects of the small existing glaciers of mountain countries and those of Alaska, Greenland and the polar regions, in comparison with the conditions we now find in our own country proves that these great ice invasions did actually occur.

Wisconsin offers an unusually good opportunity to study the effects of glaciation. The southwestern part of the state was never covered by the ice. Apparently the valleys of Lakes Superior and Michigan deflected the rush of the ice to the east and west, so that it flowed around a large area, coming together again, but leaving a great island. This island—known as the driftless area of Wisconsin—has the topography and soil of other unglaciated regions, except that the residual soil is somewhat modified by loess.

The accompanying illustration, taken

from a photograph of a carefully made relief model of the state shows the difference in topography between the unglaciated and the glaciated portions.

The effects of this glaciation on the soil and other factors affecting agriculture has been enormous. Whitbeck shows that in the glaciated portion of Wisconsin 10.5 percent more of the land is improved than in the unglaciated. In the glaciated area of the southern part of the state the uncleared land amounts to only 11 percent, while in the unglaciated portion it is 27 percent. He finds that in the sandstone belt the value of farm crops on the glaciated exceeded those on the unglaciated by 23 percent, and in the limestone section their value is 38 percent greater on the glaciated than on the unglaciated portion.

He estimates that in the southeastern portion of the state, which is fully developed, the excess in value of agricultural production amounts to \$30,000,000 annually more than it would have been if glaciation had not occurred. Expressing that sum as interest at 5 percent, it would indicate a benefit of \$600,000,000. The beneficial effects of glaciation was probably not so great in the northern part of the state, where the rocks are largely granitic and other crystalline varieties, not so much affected by ice action, but nevertheless the beneficial influence on the state as a whole could not be estimated at less than \$1,000,000,000.

Professor William H. Haas of Northwestern University has made a similar study of the effects of glaciation in Ohio. He finds that in the glaciated area of the state, 82 percent of the land in farms is improved, while but 73.6

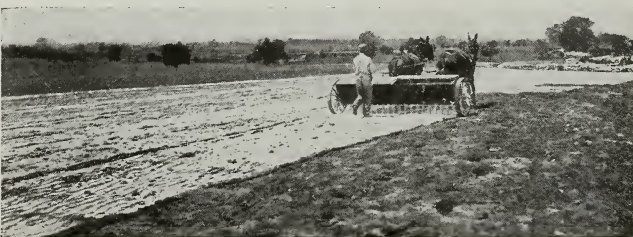
percent in the glaciated area. He also finds that the yield of wheat during the four census years, 1880, 1890, 1900 and 1910, in the glaciated area was 17.8 bushels per acre, while in the unglaciated area it was but 13.2 bushels; that the yield of corn was 39.9 bushels in the glaciated and 31.8 in the unglaciated area; the yield of oats was 36.6 in the glaciated area and 35.2 in the unglaciated area. Similar differences were found in the yields of barley, rye and hay. It is evident, therefore, that the benefits of glaciation to Ohio are greater than those found in Wisconsin, and since practically three-fourths of the state was affected by glaciation, the total benefit produced could not be estimated at less than two or three billion dollars.

With these estimates of the actual benefits which seem to have been produced by glaciation, in what ways has this improvement been produced? To just what effects of glaciation are we to ascribe this improvement? Undoubtedly among these the influence of the grinding action of the ice on the underlying limestone is very important. Professor Whitbeck's study shows that the improvement due to glaciation in the limestone region has been greater than in the sandstone region. This difference is largely due to the ice grinding the limestone rock and mixing it thoroughly with the surface soil, so that even now, thousands of years after glaciation, the subsoil is supplied with large amounts of lime and magnesium

carbonate. This carbonate leads to a larger degree of fixation of nitrogen by legumes, and also maintains the phosphorus supply in a more available form. In addition to this, it aids greatly in fixing the organic matter once produced by vegetation, so that it accumulates as humus in the soil, and in a form which will decompose readily with cultivation, setting free its essential constituents for plant use. The importance of these large amounts of lime cannot be over-estimated, but in this connection we must point out the fact that even in the glaciated limestone sections the supply of lime will not last indefinitely. In Wisconsin and other states, 50 to 75 years of cropping has already removed the lime of the surface soil to such an extent that acidity has developed, and we cannot take it for granted that lime will never be needed in the glaciated sections underlain by limestone.

Another important effect of glaciation is due to the leveling process of the ice, the grinding off of the higher hills and filling the valleys, thus reducing the relief and consequently the amount of land subject to erosion. In all probability this benefit has been as great as that due to the influence of lime.

The third improvement has resulted from the transportation of heavy soils to areas of lighter or sandy soils, with which they have been mixed, and vice versa, thus reducing the differences between heavy clays and light sands.





Arthur G. McCall, now head of the department of agronomy, was born in McGaw, Scioto County, Ohio. After completing a course in the public schools he entered Ohio State University, from which he graduated in 1900.

After graduating Mr. McCall accepted a position as scientific assistant, Bureau of Soils, U. S. Department of Agriculture, which position he held until 1904, when he came to Ohio State University as assistant professor of agronomy. He was promoted to professor of agronomy in 1905. In 1914-15 he obtained a leave of absence from the University and took graduate work in soils at Johns Hopkins University. "Physical Properties of Soils" and "Broom Corn Culture" are books published by him. Some of his technical articles are "An Artificial Root for Inducing Movement of Soil Moisture," "Ear Characteristics Not Correlated With Yield of Corn," "A Field Study of Soil Moisture," "Instruction in Soil Physics," "A New Method for the Study of Plant Nutrients in Sand Cultures," "The Absorption of Potassium by Soils," "Study of Plant Nutrients in Sand Cultures" and "The Availability of Nutrient Salts in Sand Cultures."

Mr. McCall is a member of the American Association for the Advancement

of Science, American Society of Agronomy and the American Society for the Promotion of Agricultural Science.

James E. McClintock, '06, is now supervisor of publications and correspondence work for the extension department. After completing his course at Ohio State University, he accepted a position as scientific assistant, Bureau of Soils, where he remained until August, 1907, when he became assistant professor of agronomy and supervisor of agricultural extension work at the University of Maine. In August, 1909, he went to Washington as specialist in land-grant college statistics for the United States Bureau of Education, holding this position until April, 1910, when he accepted the position as agriculturist and agricultural editor for the International Correspondence Schools at Scranton, Pa. He has been in his present position since October, 1914.

Among his published articles are "Exercises in Elementary Agriculture for Maine Rural Schools," "Feeding of Milch Cows," "Winter Thoughts About Summer Insects," and "Some Suggestions on How the Farmer and His Family May Spend the Long Winter Evenings."

Earl L. Bowser, '06, is manager of the Helvetia Condensing plant at Wellsboro, Pa.

George F. Abbott, '00, is farming and raising livestock near Chippewa Lake, Ohio.

Leland E. Call, '06, is professor and head of the department of agronomy at the Kansas State Agricultural College. After graduating Mr. Call had a fellowship in agricultural chemistry but he resigned June 1, 1907, to accept a position as assistant in agronomy at the Kansas State Agricultural College, where he has been since that time. In 1908 he was promoted to assistant professor of soils, to associate professor

in 1911 and to professor in 1913. Prof. Call completed his work for the master's degree at Ohio State in 1911 and 1912.

Joseph F. Barker, '08, is in the soils department of the New York State Agricultural Experiment Station at Geneva. Mr. Barker attended the Iowa State Agricultural College in 1909-10, where he received the degree of Master of Science of Agriculture in 1910. He was assistant professor of agronomy in the Iowa Agricultural College, 1909-11. He has been in his present position since 1911.

Floyd W. Bell, '12, is assistant professor of animal husbandry in the Texas State College.

Clarence A. Clawson, '00, is at Kansas City, where he is a veterinary inspector for the Bureau of Animal Industry.

Edward H. Bretschneider, '14, who received his degree of pharmacy in 1915, is now located with the Kauffman-Lattimer Pharmacal Company in Columbus.

Philip M. Dunlap, '08, is farming and raising livestock at Chillicothe, O.

Charles C. Ensign, '14, is located on a farm near Bryan, Ohio.

Joseph H. Gourley, '08, is head of the department of horticulture at the New Hampshire Agricultural College.

Leo P. McCann, '15, is assistant in animal husbandry at Ohio State University.

Howard Gerlaugh, '06, is running a farm at New Carlisle, Ohio.

Joseph F. Goheen, ex-'14, is a student at the University of Delaware.

Gus F. Goldsmith, '15, is with the Kelly Island Lime and Stone Company, where he is head of the publicity department.

Alva H. Benton, '12, is teaching rural economics in the University of Minnesota.

Arthur G. Abbot, '00, is on a farm at Sharon Center, Ohio. He is breeding pure bred Jersey cattle and Berkshire hogs.

Thomas K. Prugh, ex-'14, is farming near Dayton.

Charles W. Holdsen, '14, is managing a farm at Mentor, Ohio.

Clarence Siebenthaler, '15, has charge of the Siebenthaler nurseries at Dayton.

A. M. Bell, '12, is carrying on livestock farming near Utica, Ohio.

Ernest D. Blaine, '12, is farming at Mt. Sterling, Ohio. He is raising hogs as a specialty.

Wallace E. Dobbs, '12, is manager of a farm at Mentor, Ohio.

Joseph F. Cox, '12, is assistant professor of farm crops at the Michigan Agricultural College. He was formerly at the Pennsylvania State College.

W. W. Brownfield, '12, is practicing general farming at Uniontown, Pa.

C. B. Clevenger, '12, is at the University of Illinois, where he is working for a doctor's degree. He is also doing work in agricultural chemistry at the experiment station.

Everitt Brubaker, '12, is a landscape architect at Granville, Ohio.

C. B. Durham, '12, is an instructor in horticulture at Purdue University.

Donald R. Conard, '12, is a landscape architect in Columbus.

W. C. Dutton, '12, is assistant professor of horticulture at the Michigan Agricultural College at Lansing.

Carl G. Fieldner, '12, is farming and running a lumber yard at Ney, Ohio.

Paul Logan, '13, is in the orchard business near Cincinnati.

Fred C. Lisles, '15, is a graduate student in the department of farm crops.

Aaron F. Head, '15, is assistant in the soils laboratory at Ohio State University.

Raymond Gauch, '15, is a graduate student in the department of soils.



JANUARY NEWS NOTES

With more than fifty speakers of national reputation scheduled to lecture, and practically all the state-wide farm organizations meeting at the University, Farmers' Week, January 31 to February 4, promises to be the greatest agricultural event of the year.

The program, which has recently been sent out, announces the coming of Dean H. L. Russell of the University of Wisconsin; O. H. Benson and A. C. True of the U. S. Department of Agriculture, Washington, D. C.; James E. Rice, poultry expert, and E. O. Fippin, agronomist, both of Cornell University, and Rose Morgan of Columbia University.

With the annual meeting of the American Jersey Cattle Club scheduled for the week, practically all the large breeders in the United States, together with the officers and members of the club, will attend. This will bring M. D. Munn, president of the club, Minneapolis, Minn.; G. M. Gow, secretary, of New York City, and J. W. Shilling of the Chicago Dairy Produce Co., Chicago. Others coming from a distance are John A. McSparran, Master of the State Grange of Pennsylvania; John M. Irvin, owner of Duchess Skylark Ormsby, the champion cow of the world, and Irvin Priest of the Bureau

of Standards, U. S. Department of Agriculture.

The meetings of the Ohio Percheron Breeders' Association will be addressed by W. S. Corsa of Whitehall, Ill., and E. B. White of Leesburg, Va.

The Ohio Vegetable Growers' and the Ohio State Horticultural Society have secured Paul Work of Cornell University, professor of horticulture; Prof. Joseph H. Gourley of New Hampshire College of Agriculture, and W. J. Green of the Ohio Agricultural Experiment Station, Wooster.

Chief among the agronomists will be Charles E. Thorne and C. G. Williams of the Ohio Agricultural Experiment Station, and E. O. Fippin of Cornell University.

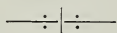
For the poultry interests of Ohio James E. Rice of Cornell University, Prof. Freeman S. Jacoby of Ohio State, Milligan C. Killpatrick, poultry extension instructor of Ohio State University; Henry Bromwell, poultry breeder, Washington C. H.; S. T. Campbell, secretary of the American Poultry Association, and Charles McClave of New London, Ohio, will lecture and demonstrate poultry practices.

Each day of the week will be given entirely to the judging of livestock by the winners of the county judging con-

tests held last fall by the extension department of the University. In round numbers, 150 will enter the contest, after which the best boy stock judge in Ohio will be named. The winners of the state-wide contest will be given medals, while the counties scoring the highest will be awarded banners.

Moving pictures will be shown in the Chapel daily at 12 o'clock. Three sessions have been planned for each day; that is, three lectures will be given hourly, allowing the farmers to pick what they want. The meetings of the associations have all been planned so that there will be no serious conflicts in time of meetings. Added to the lectures and conferences will be demonstrations in farm drainage, concrete and cement work, poultry killings and dressings, stock judging, home canning and dairying, farm architecture and farm lighting.

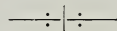
The Ohio Dairymen's Machinery Show will be held in the Armory. The Ohio State Corn Show will have their exhibits in Townshend Hall, while the demonstrations in home canning and fruit storing will be held in the Horticultural and Forestry Building. Another new feature in exhibits will be the Ohio Egg Show, in which there has already been a large number of entries. The Chapel will be used for all the evening meetings and lectures, among which Rose Morgan will give a lecture-recital, "Songs That Live." "Between Two Lives," a rural comedy, will be presented on Monday evening, January 31, by students in the college of agriculture.



Registration in the eight weeks' agricultural course compares favorably with that of 188 of the preceding year. P. L. Mark, 67, a retired minister, is the oldest man to enter. Mr. Mark

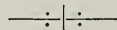
owns and operates a farm of 200 acres near Westerville, Ohio. He has two daughters who are instructors in the University.

One of the students is a native of Switzerland, who, unable to speak English, is not deterred from taking dairying. Lectures are given to the students daily except Saturday, at 4 p. m., in addition to classroom work.



W. Atlee Burpee of Philadelphia, one of the great seedsmen of the country, died at his home in that city last month at the age of 57. As founder of the seed firm of W. Atlee Burpee & Co., of Philadelphia, whose fame and prestige extend into every section of the civilized world, his energies and abilities were directed into many wide and useful channels.

Gifted with a genius for friendship he was able to attract the trustworthy sympathy and admiring affection for all who were privileged to make his acquaintance. He was an enthusiast and optimist, who combined work with pleasure, thus arousing the enthusiasm of all who were brought within the sphere of his kindly presence and personality.



Grange Election.

The University Grange elected the following officers for the year: Worthy master, T. D. Phillips; overseer, Prof. A. G. McCall; lecturer, Prof. Tom C. Stone; chaplain, Dean Alfred Vivian; steward, Prof. Robert B. Stoltz; assistant steward, William L. Clevenger; lady assistant steward, Mrs. J. Warren Smith; cerea, Mrs. James S. Hine; pomona, Mrs. Lewis M. Montgomery; flora, Mrs. Alfred Vivian; secretary, Joseph E. Fouser; treasurer, R. E. Beatty; gate keeper, J. B. Gault; chorister, Miss Chandler.

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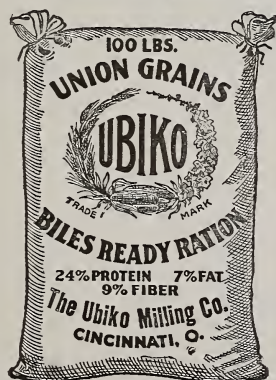
Anyone who is not thoroughly satisfied with the products raised can have his money back any time within the year, for such is the guarantee that protects all who plant seeds bought from Burpee of Philadelphia.

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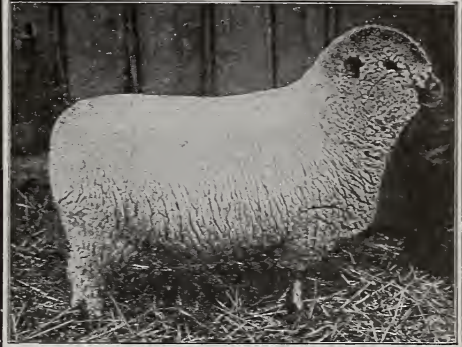
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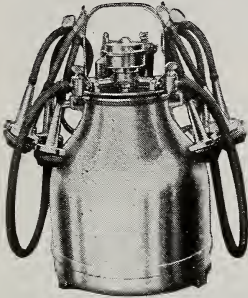
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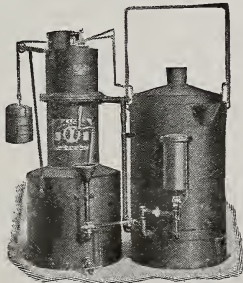
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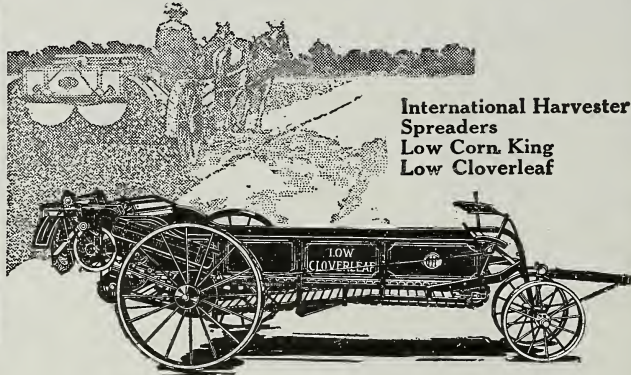
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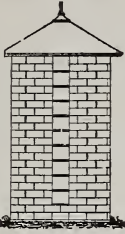
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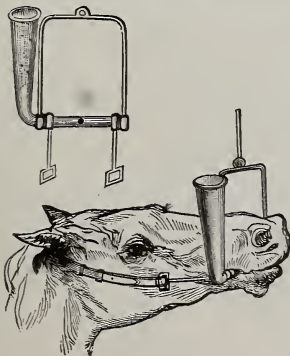
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Why Suffer Losses from Hog Cholera?

For prevention, use "544."

If your herd has been exposed, is infected and sick with cholera, treat them with "544."

"544" is a chemical substance—not a serum or virus—and is administered hypodermically.

No dangers of producing abscesses—of new centers of infection—of abortion—of stopping growth or development.

Read the letter below.

LIMESTONE VALLEY STOCK FARM
W. C. Coleman, Prop.

Butler, Mo., Nov. 1, 1915.

The Thiele Laboratories Co., Columbus, Ohio.

Gentlemen:—I have been using your "544" ever since I became aware of its manufacture, and have not had a case of hog cholera on the place since that time.

I have made a practice of treating hogs intended for market at weaning time, and that was sufficient to run them through until fattened and sold. Brood sows I have treated about once every six months with the same result.

My neighbor joining me on one side lost all his hogs this fall from cholera, while mine never missed a meal. Another neighbor, whose hogs run next to the line fence and make a complete exposure for mine, had cholera break out among his hogs this fall, and after losing one, called on the Agricultural Field Agent, who is working for the eradication of hog cholera in this (Bates) county, to vaccinate his hogs with the simple serum treatment. This was done without effect, as he lost all that was sick at the time and some that became sick later.

My neighbor called this party's attention to the fact that his neighbor (the writer) was using "544," and asked if he knew anything about the stuff. He was told that he had heard more or less about it, and that if my neighbor would just wait he would see my hogs get the cholera the same as the balance of the neighbors.

The hog cholera has left this neighborhood, as all the available hogs to work on have died, while mine alone are left.

Several have been converted to the use of "544," but at a very expensive cost.

I have delayed writing until I could see what my hogs done after such severe exposure, and have to report all well and doing fine. Never missed a meal or showed any signs of cholera.

Yours very truly,
G. C. COLEMAN.

If interested, or further information is desired, write for free booklet to

THE THIELE LABORATORIES CO.

407 Hartman Building, Columbus, Ohio.

WHY CO-OPERATION PAYS MOST MONEY FOR CREAM

Because We Pay the Freight and Give the "Tenths"

See the value of the "Tenths" to William J. Ayers, Morrow, O., who shipped us during November, 1915, as follows:

With the "Tenths" Counted.

		Cream	Test	Fat
November	1...	39.5	24.2	9.55
"	5...	37.4	24.2	9.05
"	10...	35.8	23.0	8.23
"	15...	39.9	22.6	9.01
"	20...	40.7	26.5	10.78
"	26...	39.6	22.8	9.02

55.64

Same Without "Tenths" Counted.

		Cream	Test	Fat
November	1...	39	24	9.36
"	5...	37	24	8.88
"	10...	35	23	8.05
"	15...	39	22	8.58
"	20...	40	26	10.40
"	26...	39	22	8.58

53.85

Mr. Ayers' "Tenths" gained him 1.79 pounds of fat, worth \$0.53. We paid "Freight" back to him on 6 cans at 15c, equal to \$0.90.

We sent him a check for \$17.53. \$17.53 divided by 53.85 equals 32.5c. At Elgin average price, his "Tenths" and "Freight" paid him 32.5 minus 29.9c, equals 2.6 cents above Elgin. **SHIP US YOUR CREAM.**

The West Jefferson Creamery Company

COLUMBUS, OHIO—ZANESVILLE, OHIO.

Henry Ford Uses Natco Hollow Tile

This great genius of the automobile industry builds for permanency. Ford buildings must be enduring, need few repairs, be fireproof. Natco Hollow Tile is specified. Settle your silo problem—buy a Natco. Be sure of perfect ensilage at all times. Do away with repairs and adjustments. Erect the worryless



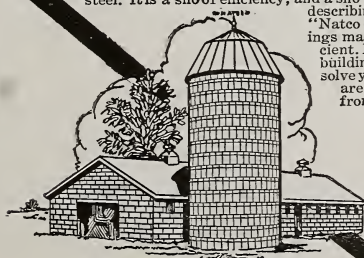
Ford Branch at Columbus, Ohio. Natco Hollow Tile was used in this building.

Natco Everlasting Silo

"The Silo that Lasts for Generations"

Its hollow, vitrified, clay tile are impervious to air and moisture—they preserve the silage sweet and juicy. The dead air spaces in the wall resist frost—making it the silo for severe climates. The continuous, reinforcing bands laid in the mortar hold it in a grip of steel. It is a silo of efficiency, and a silo you'll be proud of.

Send for our silo catalog describing it fully. Also get our splendid new book, "Natco on the Farm," describing other farm buildings made of Natco Hollow Tile and just as efficient. Both books free. We have many farm building plans to submit, and will help you solve your building problems free. What are you going to build? Let's hear from you. Write today.



A Natco Silo and a Natco Barn mean Permanency and Prosperity.

National Fire Proofing Company

1132 Fulton Building
Pittsburgh - - Pa.



Natco Silo Wall. Notice steel reinforcing bars laid in the channel.

The Use Of Hercules Dynamite[®] On Farm, Orchard and Ranch

Prepare this Fall for Spring Tree Planting

YOU can materially increase the strength and yield, and hasten the growth, of trees to be planted in the spring by dynamiting the holes for them this fall.

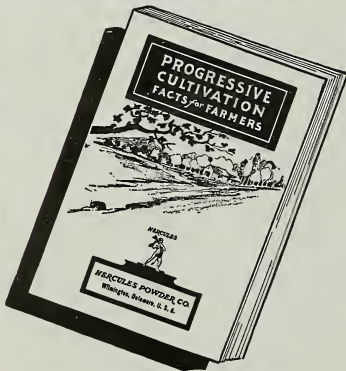
Let the holes lie open during the winter. Then plant the trees at the regular time next year.

You will be surprised at the rapid progress made by trees planted in this manner.

Hercules Dynamite breaks up the soil thoroughly for some distance around the hole. The young tender roots are thus enabled to spread and grow in a natural manner.

When two trees are planted at the same time and in the same orchard, one in a spaded hole, the other in a dynamited hole, the growth and development of the latter is invariably almost twice that of the former. This difference always shows when Hercules Dynamite is used.

If you are not thoroughly familiar with the advantages gained by using dynamite on the farm, write today for "Progressive Cultivation." It contains valuable information on tree planting, subsoiling, stump and rock blasting, drainage work and other agricultural activities.



HERCULES POWDER CO.

Fulton Bldg., Pittsburgh, Pa.

Please send me a free copy of your book, "Progressive Cultivation." I am interested in Dynamite for

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ship their
Cream to
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4 H.P. Cushman Weighs Only 190 lbs. 8 H.P. 2 Cylinder Only 320 lbs.

These are the only light-weight farm engines.
High speed and throttle governor, with perfect balance,
 give **smooth, continuous flow of power and uniform speed**
 instead of violent, irregular explosions and fast and slow
 speeds of old-style engines. This explains why Cushman engines
 are so light in weight, yet more steady-running and more
 durable than engines weighing four or five times as much.

Only All-Purpose Farm Engines

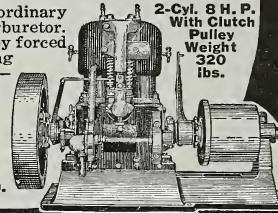
Besides doing all regular jobs, Cushman Engines may be used for so many jobs heavy engines cannot do. **4-H. P. is original binder engine**, also used on corn binders and potato diggers. **8 H. P.** used on hay balers, corn pickers, etc. **15 H. P.** weighs 780 lbs.; **20 H. P.** only 1200 lbs., for heavy duty.

Cushman equipment is much superior to that of ordinary farm engines. Friction Clutch Pulley and Schebler Carburetor. **20 H. P.** has gear-driven high tension Magneto. Cooled by forced water circulating system, permitting all-day run. Moving parts enclosed and run in bath of oil. Run at any speed—speed changed while running. If you want a real farm

Cushman Engines
are not cheap,
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engine, to run without trouble
and do all your work, you need
the Cushman. Book free.

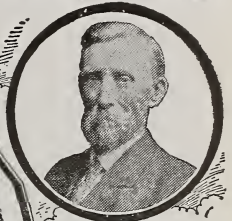
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WM. LOUDEN
The Originator



LOUDEN'S
BALANCE

GRAPPLE
FORK

Lifts Half a
Ton Without
Straining

What's One-Third of Your Time in the Hay Field Worth to You?

Louden Hay Tools will save it. Will enable you to move bigger loads easier and faster than in any other way—avoid the danger of delay which often lets the rain catch your hay down, spoiling it for use or sale.

Louden Balance Grapple Fork

Set the Louden Balance Grapple Fork across a load and it will take the entire width of an 8-foot rack at a single lift. Half a ton at a time will not strain it. You can put away the biggest load in five minutes. Moves straw, alfalfa, or clover as clean as timothy—grips it tight; no scattering or dribbling. What other hay fork will do this? Built of the finest steel, especially made for us. Light, strong, perfectly balanced, never fails.

Louden Hay Sling is the tool you want for heavy work in short forage. Its factory test is 3,000 pounds. Will handle anything in the way of roughage without waste. Nothing to beat it as a time and labor saver.

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meets the needs of the hay grower for ordinary and for extra heavy work. Has a guaranteed continuous working capacity of 1500 pounds. Louden Swivel Frame prevents rope troubles; roller-bearing rope wheels make it easy to operate. Can be used for either end or center drive. You can pick up a load off the wagon from any angle—it never fails to register. Draws its load right up against the track, drags it over beams and puts it right where you want it every time. You can store tons more hay in the same space and in record time.

Louden Power Hoist Works with all the Louden Hay Tools. One man operates it from the load—takes the place of horse or team on the draft rope; saves you \$5 a day when used with a Louden Carrier Fork, or Sling. It's simple, smooth-running, powerful. Operates with steam, gasoline engine or electric motor. Will MAKE GOOD wherever hoisting power is needed.

Louden Hay Tools are dependable all times. They cost little; save time; save labor and they often save the crop. Write for our big, new, illustrated catalog on Louden Hay Unloading Tools. Sent free on request.

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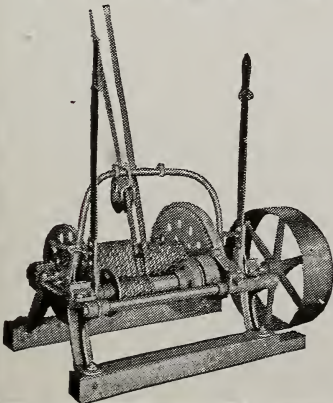
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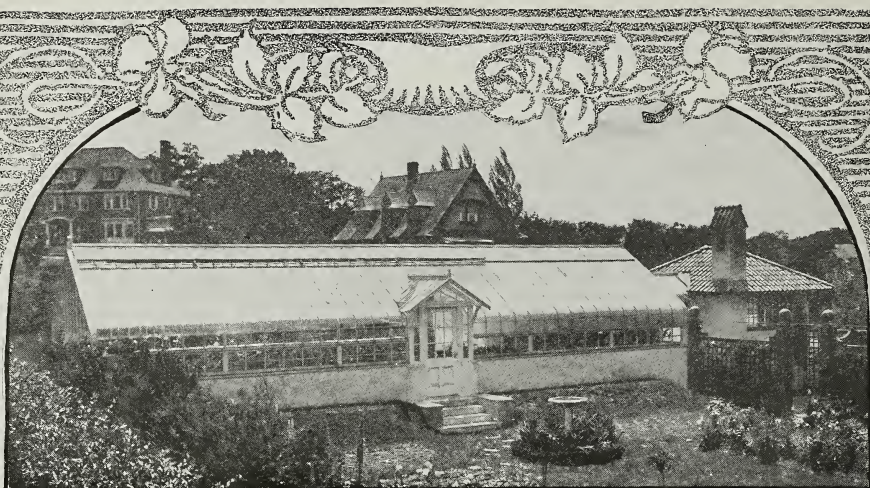
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How To Go About Buying A Greenhouse

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There are worries about it—but that's **OUT** END of it. We will, if you wish, do every part of the work from the turning of the sod to turning on of the heat in your completed glass garden.

The first thing to do now, is send for our "Two G's Booklet," or "Glass Garden, a Peep Into Their Delights," and see if there are any subjects in it that seem to meet your needs. If so, we can promptly give you a price on any one of them complete.

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All these preliminaries can generally be carried on by correspondence; but frequently it is an advantage to have one of us come right to your grounds, look over the proposed location and talk things over generally with you. This we are always glad to do. It often results in our being able to make several advantageous suggestions.

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